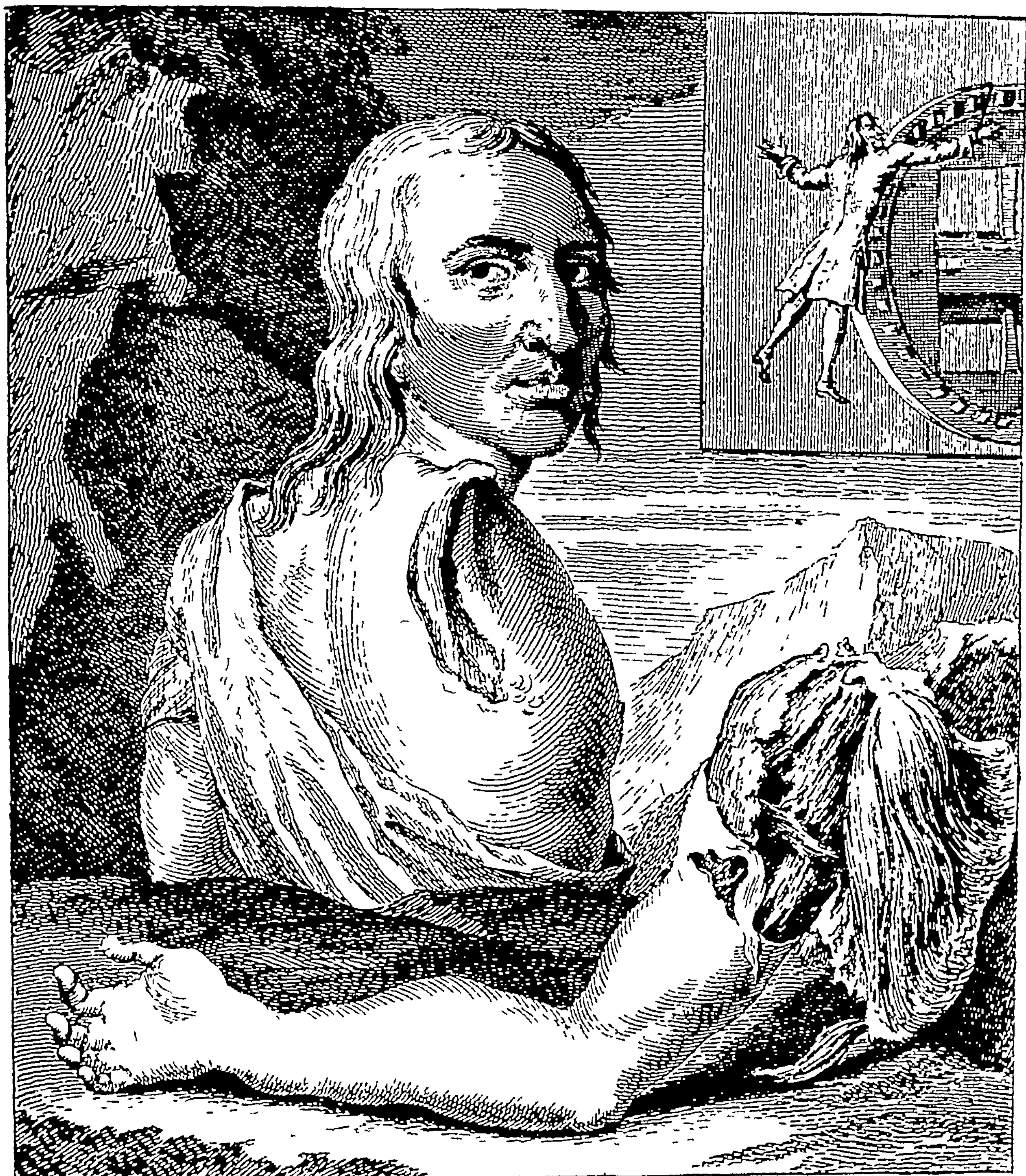


SAMUEL WOOD Whose Arm with the Shoulder blade was torn off by a Mill y^e 15^th of Aug 1737 He was brought to S^t Thomas's Hospital y^e next day Where he was Cured by M^r Ferne

Publish'd by Samuel Wood According to Act of Parliament Nov 1^st 1737

The Forequarter Amputation

BY

H. F. MOSELEY
M A , D M , M Ch (Oxon), F R C S (Eng and Canada), F A C S
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ILLUSTRATED BY

HELEN T MACARTHUR, B A

With 11 Plates in Colour
and 25 Figures in Black and White



E. & S. LIVINGSTONE LTD.
EDINBURGH AND LONDON
1957

THIS WORK IS
DEDICATED TO

JOHN THOBURN WILLIAMSON
B A, M Sc, Ph D D Sc

Graduate of McGill University, and Canadian Geologist whose scientific knowledge, industry, and spirit of adventure guided him to his life's work in the diamond fields of Tanganyika

Printed in Great Britain

Preface

The incentive to assemble these materials for publication originated when three patients requiring a forequarter amputation presented in close sequence

On consulting the literature, it appeared that a contribution would be made by providing a short monograph covering the historical aspects, the anatomical considerations, indications, and operative procedures, with the chief emphasis placed on the detailed surgical anatomy of this region as it applies to the forequarter amputation whether performed by the Berger or the Littlewood technique As the project developed, the inclusion of scapulectomy seemed necessary in order to define the indications more accurately and to review the knowledge on this partial ablation of the shoulder girdle

Further, it seemed worth while to include a chronological case recording of the traumatic avulsions of the forequarter, since such an up-to-date listing did not appear in the surgical literature This tabulation is as complete as seemed practical and justifiable in relation to this project Statistical studies relating to the operative procedures for neoplastic disease will be found in the articles of Rogers, Buchanan, de Nancrede, Pack, and others quoted in the text and reference list

The coverage of this monograph thus appeared to be a logical extension of the author's publication " Shoulder Lesions," yet too detailed and specialised to include in a future edition of that work

Although in the future radical surgery for neoplastic disease may be largely outmoded by chemotherapeutic advances such as we have witnessed for infective processes, it is hoped that this work will assist those who must undertake these major procedures in the intervening period

H F MOSELEY

Montreal, Canada
1957

Acknowledgments

During the assembly and review of the materials for this monograph the author has been keenly aware of the assistance, readily visible throughout this volume, which he has received from various individuals and numerous sources of reference

In the first place, appreciation must be extended to Miss Helen MacArthur, Medical Illustrator at the Royal Victoria Hospital, who has not only produced all the beautiful and accurate drawings but has also assisted in the dissections, library research, and integration of the materials Her valuable help on this project, which represents our sixth book publication together, is herein recorded

Those acquainted with the surgical literature will realise the debt that the profession and the present author owe to Dr George T Pack, whose writings are the modern classics on this interesting subject His advice has been of the greatest assistance in preparing this work, which reflects many of his contributions

Further materials have been provided by Dr Charles O Bechtol, Dr James C Callahan, Dr Bradley Coley, Dr G E Haggart, Dr Harrison McLaughlin, Dr E S James, Dr E J Tabah, Dr Paul Weil, and Dr W W Werley Such contributions have been acknowledged where possible in the text

Anatomical dissections which formed the basis of most of the colour plates and drawings were facilitated by Dr S M Banfill of the Department of Anatomy of McGill University

The literary research was executed through the libraries of the McGill Medical School, of the Royal College of Surgeons of England of the American College of Surgeons and the National Library of Medicine in Washington The services of Mr W R le Fanu and Mr Samuel Wood of the Library of the Royal College of Surgeons were utilised to provide the greater part of the case records of the traumatic avulsions of the forequarter

Mrs Max Slapack has been responsible for the careful preparation of the manuscript

The publication of this monograph has been assisted by a grant-in-aid from McGill University through the kind services of Principal Cyril James, which is gratefully acknowledged

Finally my appreciation extends to Mr Charles Macmillan and E & S Livingstone Ltd, who have accepted these materials for publication and produced them in their present form

H F M

Table of Contents

Colour Plates

I
Historical Aspects

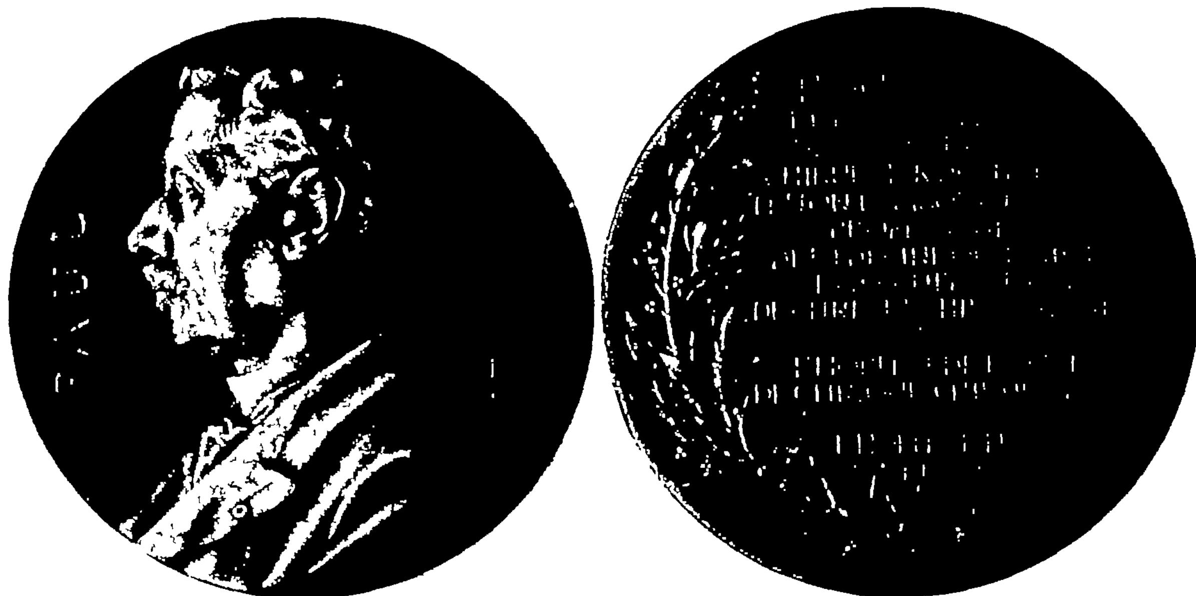


FIG 1
Professor Paul Berger Commemorative medallion (in possession of author)

SEARCH of the surgical literature on the subject of the forequarter amputation and of partial and total scapulectomy quickly the wealth of knowledge and understand- h remains dormant in our libraries until dent, stimulated by the necessity of appre- more about a problem, undertakes to learn lessons of the past The more detailed culous the investigation, the more certainly come apparent that the ideas and techniques gradual evolution Certain periods will be ien the particular subjects came into focus, e periods will be found to coincide with the on in written form of the available know- that time Such classic works when studied on to the period will reveal that many indi- were interested in the particular problem at that time and contributed to the ev thought, but only the recorded word persi us cognisance Thus to-day most writers to Paul Berger (Fig 1) the operation of quarter amputation because in 1887 he monograph detailing all aspects of thi However, the student will realise that no involved originated with him, and his co was the assembly of materials and focusi gical interest on this particular subject this realisation that the present author s his endeavour after several years' study of interesting field

Our history begins with the case record Wood (Fig 2), a miller whose arm became in the rope of his mill-wheel and who traumatic avulsion of the whole limb an



FIG 2
Cheselden s illustration of Samuel Wood 1 Prominence of clavicle , 2 The wound 3 Subscapularis muscle , 4 Fractures of the radius and ulna in two places

shock or hæmorrhage occurred at the time e accident and the patient was taken to St nas's Hospital London, where he made a rapid ry with simple dressings (1737) An account s remarkable case with an excellent engraving was recorded by Belchier[116] and again Cheselden, *The Anatomy of the Human Body*, 1768[21] This case served to demonstrate that the human body could withstand the shock of such a major mutila tion Periodic reports of similar cases have appeared

in the medical journals from that time up to the present day, and an attempt has been made to list the published cases in chronological order in Chapter VII of this book [110 172]

communication reference is made to a case seen in Greenwich Hospital twenty-one years previously (1808) (Fig 3, A) Later correspondence indicated that the examination was made at St Bartholomew's

REMOVAL OF THE ARM, SCAPULA, AND CLAVICLE.

To the Editor of the London Medical Gazette

SIR,

IN the last number of the Gazette, I have read with much interest a detailed account of the partial excision of the scapula, by Mr Luke, of the London Hospital, on account of medullary sarcoma having taken root on a portion of that bone, and which appears to have been performed successfully, and in a masterly manner, by that gentleman

I do not know whether the case be published, but in 1808, whilst doing duty at Greenwich Hospital, a young sailor, about 21 years of age, presented himself for a pension on account of the total removal, by operation, of the arm, scapula, and clavicle, and I perfectly remember our sending the man to the College of Surgeons, or to some one of the London hospitals, to be there examined as to the successful result of this formidable operation Gun-shot wound, I think, was the injury inflicted, and the operation was determined on and performed by Dr. Ralph Cuming, then surgeon to the Naval Hospital at Antigua. Should you deem this notice of the case worthy of record, I beg you may insert it in your valuable journal.

Your's,

A COPLAND HUTCHISON.

Duchess Street, Portland Place,
23d Nov 1829

104 —V

FIG 3A

AMPUTATION OF THE SCAPULA, &c.

To the Editor of the London Medical Gazette.

SIR,

IN your next number I will thank you to explain to your correspondent, J M, that *you* were the aggressor, by heading a note with my signature affixed to it, as if *I* had been the operator, by which he professes himself to have been a disappointed reader,—and at the same time inform him that the case in question was sent to the surgeons of St Bartholomew's Hospital for examination.

Should your correspondent J M. wish for information as to the professional character of the operator mentioned in my note (Gazette, 28th Nov. 1829), refer him to the "Naval, Military, and Private Practitioners Emanuensis, Medicus et Chirurgicus, &c. by Ralph Cuming, M D. R.N Medical Superintendent of his Majesty's Naval Hospital, Antigua; published by Mathews and Leigh, 18, Strand, 1806"

Yours,

A COPLAND HUTCHISON

Jan. 18, 1830

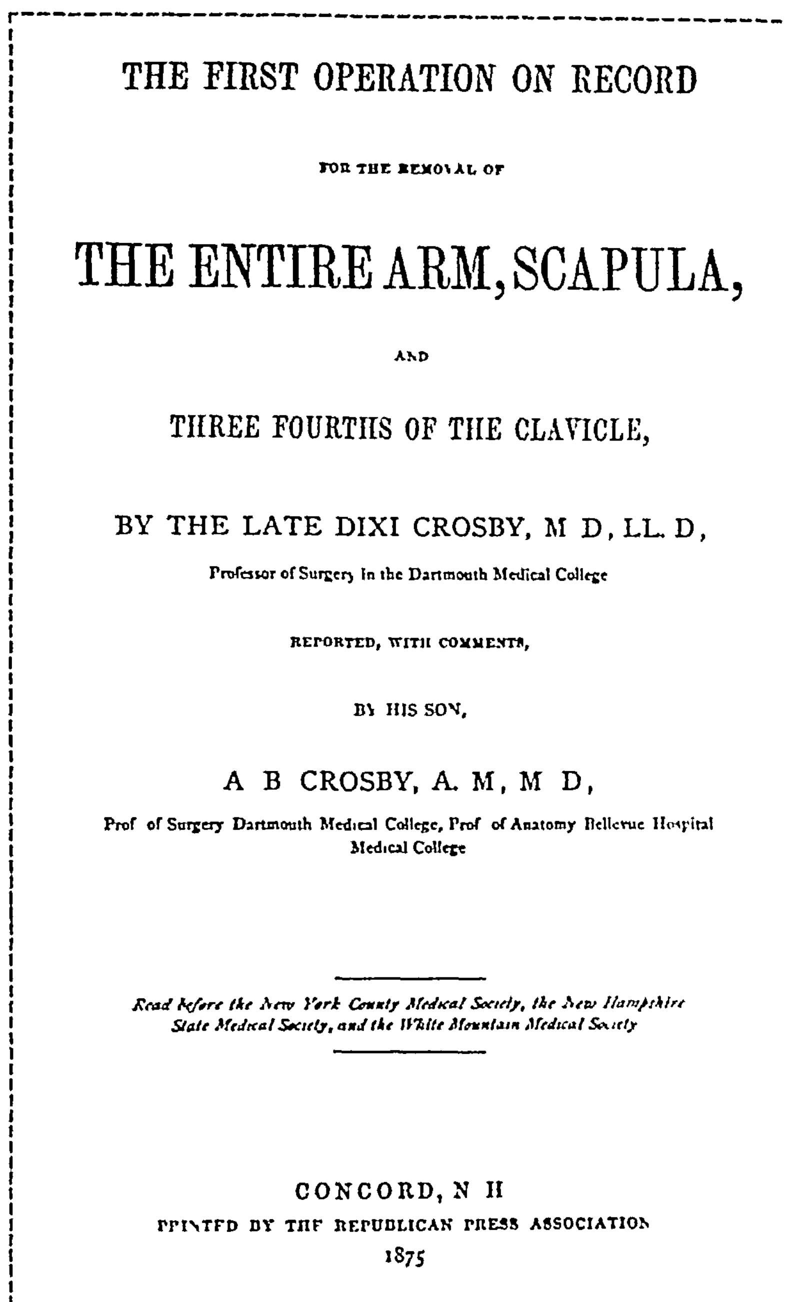
[The heading alluded to was on the wrapper, which we are fain to leave to the discretion of the printer. A notice of the case in question will be found in the edition of Cooper's Surgical Dictionary just published, page 564 We are informed by Mr Hutchison, however, that though the injury requiring the operation was inflicted by the shot, yet that the amputation of the humerus scapula and clavicle was performed by the surgeon. This he ascertained by a reference to the original document]

FIG 3B

FIG 3
Original references to the first case of forequarter amputation for a gunshot injury

The first surgical removal of the forequarter is generally attributed to a young English naval surgeon and was performed for a gunshot wound Keevil[58] has investigated and published the historical basis of this priority, which rests largely on letters of A Copland Hutchison, F R C S, to the *London Medical Gazette* 1829 and 1830 [49 50] In the first communication reference is made to a case seen in Greenwich Hospital twenty-one years previously (1808) (Fig 3, A) Later correspondence indicated that the examination was made at St Bartholomew's Hospital and that the forequarter was removed by operation and not by the original gunshot trauma (Fig 3, B)

In 1819 partial scapulectomy was successfully executed by Liston[70] of Edinburgh The infraspinous portion was removed for "osteo-aneurysm" Great hæmorrhage was encountered, but the patient with-



THE FIRST OPERATION ON RECORD

FOR THE REMOVAL OF

THE ENTIRE ARM, SCAPULA,

AND

THREE FOURTHS OF THE CLAVICLE,

BY THE LATE DIXI CROSBY, M D, LL. D,

Professor of Surgery in the Dartmouth Medical College

REPORTED, WITH COMMENTS,

BY HIS SON,

A B CROSBY, A. M, M D,

Prof of Surgery Dartmouth Medical College, Prof of Anatomy Bellevue Hospital Medical College

Read before the New York County Medical Society, the New Hampshire State Medical Society, and the White Mountain Medical Society

CONCORD, N H

PRINTED BY THE REPUBLICAN PRESS ASSOCIATION

1875

FIG 4

Title page from the publication describing Dr Dixi Crosby's case, the first forequarter amputation for neoplasm

stood the operation When a recurrence of the tumour occurred Liston proposed resection of the remaining portion of the scapula but failed to obtain the sanction of his colleagues The patient died five months following the initial operation from repeated hæmorrhages

Dr Dixi Crosby,[20] an American surgeon first removed " the entire arm, scapula, and three-fourths of the clavicle " for a malignant growth (1836) It is reported as an " osteo-sarcoma " which weighed twenty-five pounds after removal The patient survived the operation only to die twenty-eight months

later from paraplegia presumably due to metastases (Fig 4)

In the following year, 1837, Mussey,[82] who had refused to operate on the preceding case because of the formidable procedure involved, performed the first total scapulectomy with the clavicle for a recurrent chondroma Previously disarticulation at the shoulder joint had been done The patient was followed and was free of recurrence thirty years later

The priority for the first total scapulectomy with preservation of the upper limb is generally accredited von Langenbeck (1855) This case was reported by his assistant Fock,[40] and was performed on a boy aged 12 years whose whole scapula was involved in a malignant tumour, presumably an osteogenic sarcoma Primary healing was secured but recurrence followed in seven weeks and death 109 days after the operation

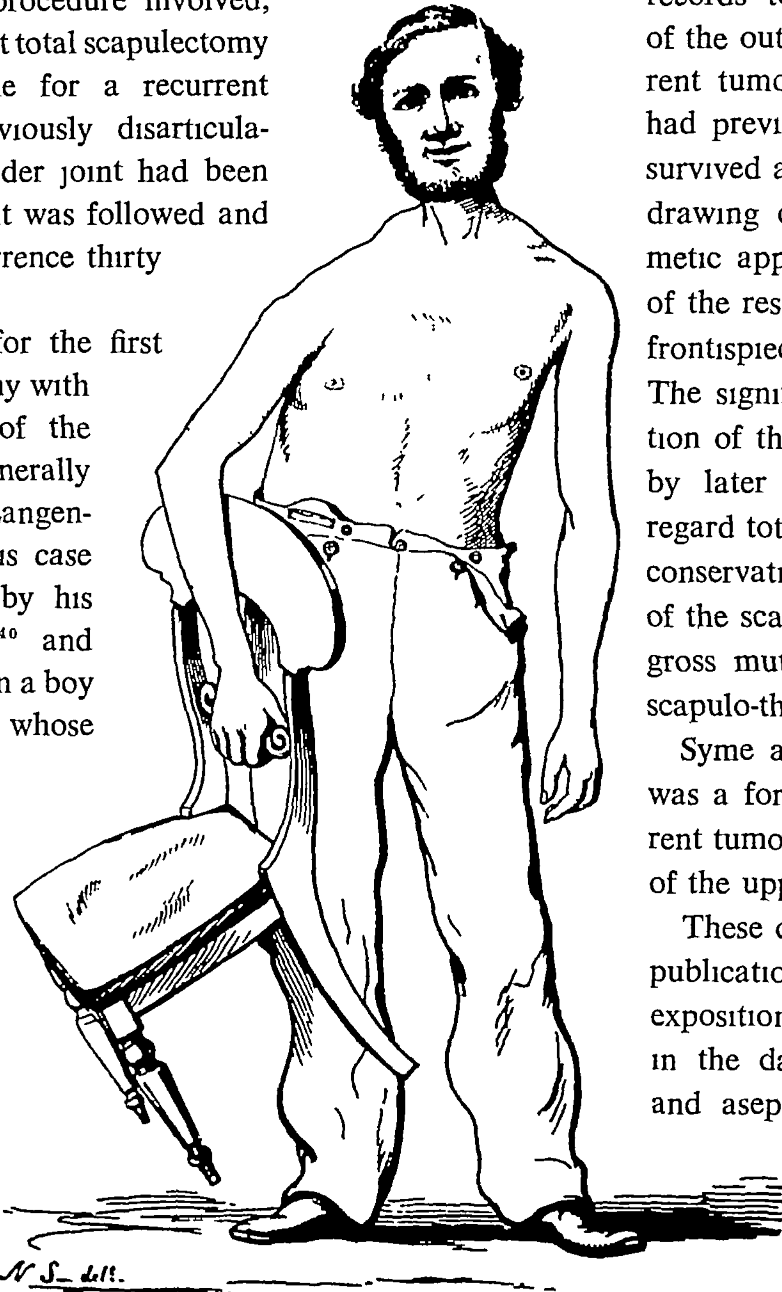


Fig 5

The frontispiece of Syme's monograph depicting the appearance and function of the upper limb after total scapulectomy

Certain authors have regarded Syme[105] of Edinburgh as the first to perform total scapulectomy for a tumour This probably resulted from the ready availability of his monograph, *Excision of the Scapula*, 1864 The first case presented is one of total scapulectomy for an angiomatous growth (1856) The patient, aged 70, made a good recovery from the operation but succumbed ten weeks later from "senility"

The second case is of greater interest as it records total scapulectomy with removal of the outer end of the clavicle for a recurrent tumour for which the humeral head had previously been resected The patient survived and worked as a postman A line drawing of this patient showing the cosmetic appearance and functional qualities of the residue of the upper limb forms the frontispiece of Syme's monograph (Fig 5) The significance of this case in the evolution of thought on our subject was its use by later writers[35, 93] and authorities to regard total scapulectomy as the essence of conservative surgery for malignant growth of the scapula, and much preferable to the gross mutilation resulting from the interscapulo-thoracic amputation

Syme also recorded a third case which was a forequarter amputation for a recurrent tumour previously treated by resection of the upper end of the humerus

These cases constitute some of the early publications bearing on the subject of our exposition The courage of these surgeons in the days before anæsthesia, antiseptic and aseptic surgery, the antibiotics, and blood transfusion commands our respect and admiration Such records constitute the foundation of our present-day practice

In time summaries of the extant knowledge began to appear In 1868 Dr Stephen Rogers[96] reviewed the history of total scapulectomy, and stated that the operative procedure was standardised meriting a definite place in the surgical treatment of malignant disease

L'AMPUTATION DU MEMBRE SUPERIEUR

DANS LA CONTIGUITÉ DU TRONC

(AMPUTATION INTERSCAPULO-THORACIQUE)

PAR

PAUL BERGER

CHIRURGIEN DE L'HOPITAL TENON
PROFESSEUR AGRÉGÉ A LA FACULTÉ DE MÉDECINE
MEMBRE DE LA SOCIÉTÉ DE CHIRURGIE

Avec figures dans le texte

Et 2 planches en chromolithographie

PARIS

G MASSON, EDITEUR

LIBRAIRE DE L'ACADÉMIE DE MÉDECINE

120 boulevard Saint-Germain en face de l'École de Médecine

1887

FIG 6
The title page of Berger's classic monograph on the forequarter amputation

Paul Berger's classic monograph *L'Amputation du Membre Supérieur dans la Contiguité du Tronc* (*Amputation Interscapulo-Thoracique*)[12] appeared in 1887 (Fig 6) This has been the basis of most writings since that period as it details the history, indications, and technique of the operative procedure, stressing the necessity of preliminary ligation of the subclavian artery and vein originally practised by Ollier.[63] This publication occurring in the post-Listerian era which enjoyed the development of

anæsthesia stimulated surgeons to undertake these major ablations for malignant disease in increasing numbers

At the turn of the century the published articles show that greater attention was being directed to the selection of cases and to the study of the end results obtained

Careful statistical tables such as those of Buchanan (1900)[21] and Fowler[41, 42] listed the published cases with the follow-up recorded where possible De Nancrede (1909)[32, 33] reviewed the position of total scapulectomy for sarcoma and concluded that this operation held little promise for such neoplasms involving this bone and must be regarded as palliative in nature He postulated a greater chance of survival for such patients from the more radical forequarter amputation

In view of the failure of total scapulectomy for malignant disease spreading from the scapula, the interscapulo-thoracic resection* was proposed by Ashhurst,[5] Tikoff,[107] later Bauman,[8] and Linberg,[69] for those patients who refused the total ablation of the extremity

A further contribution to the technical aspects of the forequarter amputation was advanced by Littlewood (1922),[60, 71] who advocated this major ablation from the posterior aspect

In recent years the papers of Dr George T Pack[86, 90] and Dr Bradley Coley[27] and their colleagues from the Memorial Hospital for Cancer and Allied Diseases, New York, have given the profession the most carefully compiled and accurate information yet available on the indications and results to be expected from the various operative procedures under consideration for neoplastic disease Their publications also bear witness to the great advance in surgical technique available to the patient at the present day In twenty-nine recorded forequarter amputations before 1881 (pre-Listerian) the mortality was 38 per cent In Berger's series up to 1887 the rate was approximately 20 per cent in a series of twenty-two cases Buchanan details 141 operations up to 1900 with a figure of 12 per cent [19, 21] Pack (1942) adds an additional 180 cases from the literature with a mortality of 5 per cent, but in his own personal series of thirty-one cases there was not a single operative death In 1956 Pack's series contains eighty-eight cases of forequarter amputation and 140 other cases of major exarticulations of the lower limb at the hip joint and hindquarter amputations without operative mortality, surely a triumph for the progress of surgical technique

To-day these major procedures can be safely performed, the problem resolving itself to a careful selection of the cases and choice of the procedure most likely to cure or relieve the pathological lesion under treatment

* Removal of the scapula, upper end of the humerus, and portion of the clavicle

II

Anatomical Considerations

IN this chapter the surgical anatomy necessary for understanding the various partial and complete ablations of the shoulder girdle will be described in detail The method employed is that utilised by the author in previous publications,[74 81] namely to build up the anatomical structures from the deeper to the superficial planes while in the operative procedures which follow the dissection will be reversed in order In this manner the important relations will be fully covered when the two chapters are correlated

Plates I and II will depict the relations of the shoulder girdle from the anterior aspect, while Plate III will illustrate the anatomy from the posterior aspect

To simplify the description and illustrations, the lymphatic vessels and glands and the fascial planes related to the subclavian and axillary vessels will be omitted from the first three plates The lymphatic structures will be seen in a separate drawing (Plate IV), while the fascial planes will be best considered in the operative series (Plates VI and VII) An understanding of the fasciæ in this region is essential in the exposure of the neurovascular structures by the anterior approach

Plate I

ANTERIOR RELATIONS OF THE SHOULDER GIRDLE

In this plate three illustrations build up the anatomical relationships of the shoulder girdle to the trunk and detail the neurovascular structures involved in the forequarter amputation in their positions relative to the thoracic operculum and base of the neck The lymphatic glands and channels have been omitted for simplicity (*see* Plate IV)

In Figure A our vision should be centred on the first rib on to which the scalenus anterior is inserted Above this rib and on the deepest plane the dome of the pleura covered by Sibson's fascia is noted Muscles which form a part of our story are the intercostals, the subclavius arising at the costochondral junction of the first rib, the pectoralis minor arising from the second, third, and fourth (and fifth) ribs, and the serratus anterior arising by digitations from the upper eight to nine ribs The superior digitation is of especial interest, originating on the first and second ribs near the anterior border of the scalenus medius and scalenus posterior and passing backwards to attach to the superior angle of the scapula as shown in Figure B

The subclavian artery is seen passing upwards from the superior mediastinum over the dome of the pleura For descriptive purposes it is divided into three parts by the scalenus anterior *part one* includes that portion extending from its origin from the innominate artery on the right side (or from the aorta on the left side) to the medial border of the muscle, *part two* lies behind the muscle, and *part three* extends from the lateral border of the scalenus anterior to the lateral border of the first rib where the subclavian becomes the axillary artery Of the various branches of the subclavian artery, two

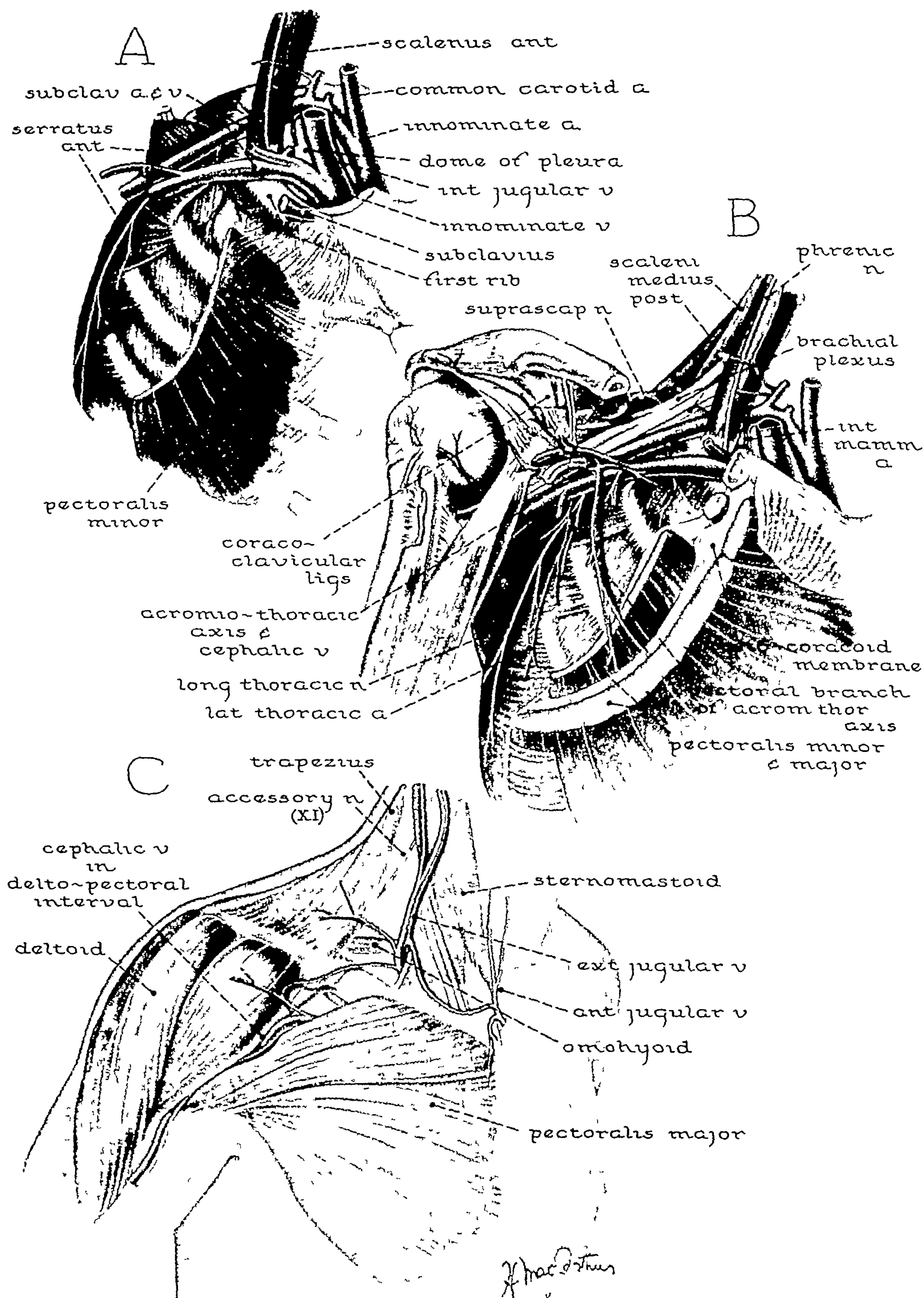

A
scalenus ant
subclav a. c̄ v.
common carotid a
serratus ant
innominate a
dome of pleura
int jugular v
innominate v
subclavius
first rib
pectoralis minor
B
scaleni medius post
phrenic n
suprascap n
brachial plexus
int mamm a
coraco-clavicular ligs
acromio-thoracic axis c̄ cephalic v
coracoid membrane
long thoracic n
pectoral branch of acrom thor axis
lat thoracic a
pectoralis minor c̄ major
C
trapezius
accessory n (XI)
cephalic v in delto-pectoral interval
sternomastoid
deltoid
ext jugular v
ant jugular v
omohyoid
pectoralis major

PLATE I

especially are encountered in the forequarter amputation, *i e*, the transverse cervical and the suprascapular arteries Some variability in the transverse cervical artery will be found Further information on these vessels will be given in the legend for Plate II

The axillary vein, after being joined by its tributary the cephalic vein, runs proximally over the first rib to become the subclavian vein The subclavian vein lies on a more anterior and inferior plane than the artery and is joined by the external jugular vein before joining the internal jugular to become the innominate vein behind the sternoclavicular joint As will be found at operation, the subclavian vein on its posterior and inferior aspects is firmly fixed to the first rib by a strong fascia and also to the lateral edge and posterior surface of the rhomboid (costoclavicular) ligament In the early operative reports, tearing of the vein in this area complicated by severe hæmorrhage and air embolism was sometimes the cause of death

In Figure B part of the structures of the shoulder girdle have been applied The middle third of the clavicle the underlying subclavius muscle and the related fasciæ have been omitted to permit depiction of the neurovascular structures as seen in the second step of the classic Berger interscapulo-thoracic amputation The scalenus medius and posterior are added, and in the cleft formed with scalenus anterior the brachial plexus is found Note the coraco-clavicular (conoid and trapezoid) ligaments which bind the clavicle to the coracoid process In scapulectomy it may be preferable to section the clavicle medial to these ligaments rather than to disarticulate at the acromioclavicular joint and sever these ligaments

Three nerves should be studied since they are found at operation ·

1 The phrenic nerve, a localising landmark on the scalenus anterior which can be palpated digitally
2 The suprascapular nerve, (C_4), C_5, C_6, which descends to enter the suprascapular notch below the artery and vein, all of which are severed in the forequarter amputation (*see also* Plates X, XI)
3 The long thoracic nerve of Bell, C_5, C_6, C_7, (C_8), descending behind the brachial plexus and the axillary artery and vein to run upon and supply the serratus anterior (*see also* Plates X, XI)

The pectoralis major, the pectoralis minor, and the subclavius muscles with their related deep fasciæ are seen in section on the right hand side of the drawing They form with the clavicle the main anterior barrier to the subclavian vessels and are transected in the operation Details of the fascial planes will be described under the operative procedure (Plate VI) Branches of the acromiothoracic axis supplying the pectoral muscles are seen in part in this drawing, but do not create any serious problem at operation

In Figure C the superficial musculature and venous channels are added The deltoid and pectoralis major form one massive muscle sheet separated by an indefinite deltopectoral cleft in which the cephalic vein courses in variable manner The trapezius laterally and the sternomastoid medially attach to the clavicle in extents corresponding roughly to those of the deltoid and pectoralis major respectively A venous channel may connect the cephalic and external jugular veins over the bare central portion of the clavicle The superficial connection of the anterior with the external jugular vein is shown, the latter passing deeply to enter the subclavian vein It should be noted that these large veins provide difficulties in the anterior dissection when performing the amputation under consideration Furthermore, gross enlargement and variations in both the arteries and veins will be found when the area is exposed in the presence of massive tumours

Plate II

ANTERIOR RELATIONS IN THE SUPRACLAVICULAR REGION

The purpose of this illustration is to give in greater detail and from a more superior viewpoint the relationships depicted in Figure B of the preceding plate Again the lymphatics and fasciæ have been excluded for diagrammatic purposes For the correlation with the forequarter amputation performed in the classic Berger manner, one notes here chiefly the positions and interrelationships of the brachial plexus and the subclavian vessels with their branches

The viewer should first study the longitudinal muscles From before backwards these are the scalenus anterior, passing to its insertion on the first rib, on whose superficial surface the phrenic nerve courses downwards and medially posterior to the subclavian vein to join the internal mammary vessels in their passage to the mediastinum, the scalenus medius and posterior descending to insert on the first and second ribs, and most posteriorly the levator anguli scapulæ which inserts on the superior angle of the scapula In relation to the levator scapulæ note the spinal accessory (cranial XI) nerve This nerve descends from the surface of the transverse process of the atlas in the deep substance of the sternomastoid muscle, leaving the posterior border thereof at the junction of its superior and middle thirds to course across the posterior triangle in a downwards and backwards direction It enters and supplies the trapezius muscle on its deep surface at the junction of the middle and inferior thirds of its anterior border The horizontally directed muscles, the supraspinatus and the first digitation of the serratus anterior, should be especially studied The superior portion of the long thoracic nerve can be seen on the surface of this digitation The cords of the brachial plexus are found in the cleft between the scalenus anterior and scalenus medius Note the suprascapular nerve which is joined by the suprascapular vessels running in close association with the posterior belly of the omohyoid muscle to the region of the suprascapular notch This group of structures is sectioned in the detachment of the scapula (*see also* Plate XI)

The subclavian artery in its close relation to the dome of the pleura can be seen passing behind the scalenus anterior At operation it is secured in its third portion and one can understand the possibility of entering the pleural space when freeing its posterior surface

Two branches of the subclavian artery are separately tied in the interscapulo-thoracic amputation (1) the suprascapular artery, and (2) the transverse cervical artery Some mention should be made concerning the variations of this latter vessel Sometimes the thyreocervical trunk arising from the first part of the subclavian artery gives off two posteriorly directed branches, the suprascapular and the transverse cervical arteries This latter artery divides into an ascending ramus (O T superficial cervical) and a descending ramus (O T posterior scapular) In this arrangement branches of both rami will be tied in our operation The variation occurs when, as in our illustrations, the descending ramus arises as a separate branch from the third (or second) part of the subclavian artery and courses through the cords of the brachial plexus This descending branch is then called the descending scapular artery, and the separate ascending branch the superficial cervical artery In this instance both the superficial cervical and the descending scapular arteries will require ligation at operation (*see also* Plates X, XI)

Attention should now be directed to the subclavian vein and its tributaries The ligation of the main vessel just distal to its junction with the internal jugular is usually the most difficult step in the operation It is closely adherent to the first rib and to the costoclavicular (rhomboid) ligament The vein wall is easily torn in the dissection and, as previously mentioned, serious hæmorrhage and air embolism have been frequently reported. Puncture of the vein can also be produced by the sharp cut

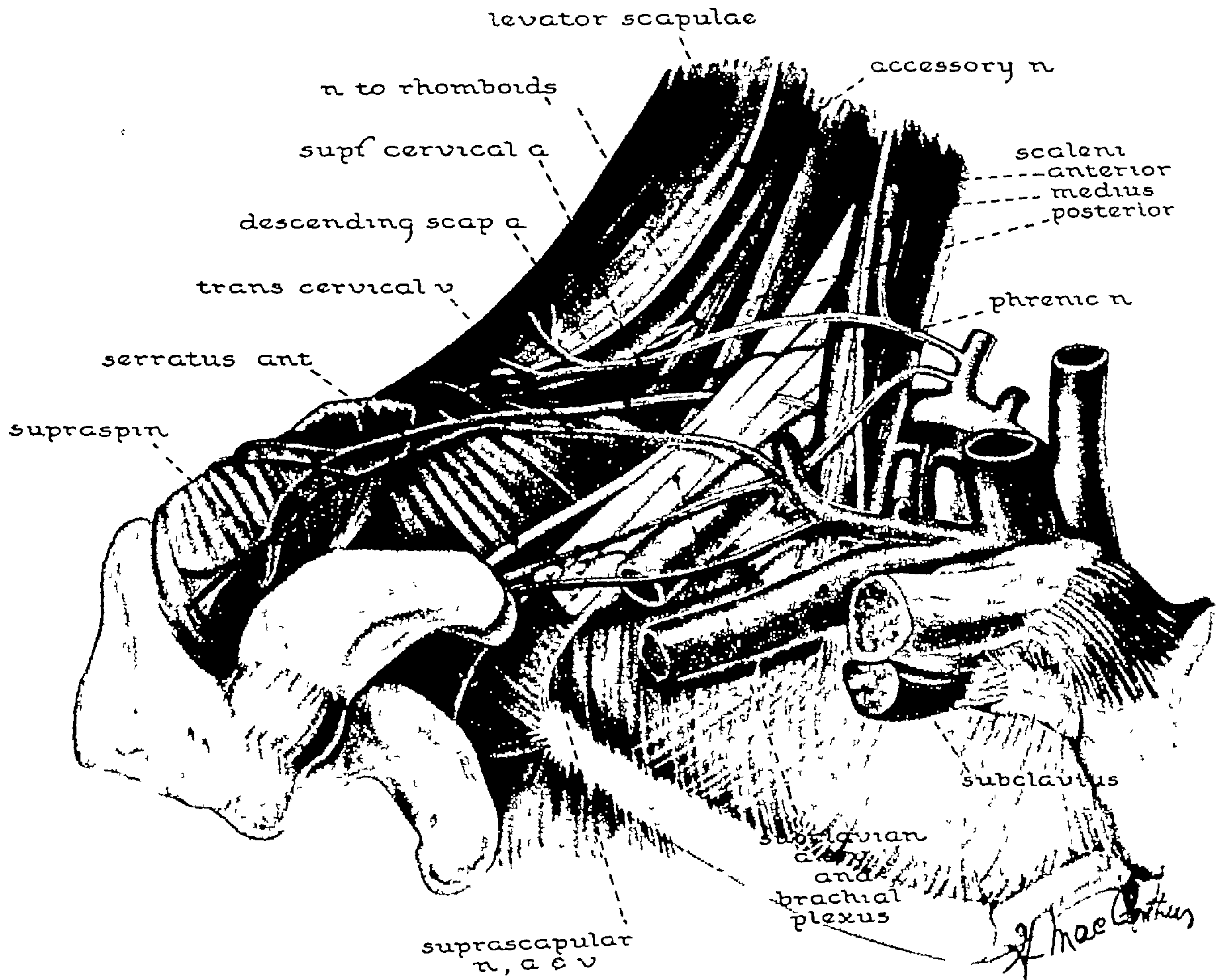

levator scapulae
accessory n
n to rhomboids
supf cervical a
scaleni
anterior
medius
posterior
descending scap a
trans cervical v
phrenic n
serratus ant
supraspin
subclavius
subclavian
and
brachial
plexus
suprascapular
n, a & v

PLATE II

end of the lateral fragment of the clavicle when the limb is manipulated away from the body The close relationship with the posterior aspect of the sterno-clavicular joint and sternal end of the clavicle should be emphasised The sternohyoid and sternothyroid muscles serve as buffers In the classic Berger operation the sternal end of the clavicle is left in situ and this is recommended unless the lymphatic glands in this area require removal as in carcinomatous lesions of the upper extremity with axillary metastases If the sternal end of the clavicle must be removed, it is absolutely necessary to dissect directly on the bony surface

Our comments on surgical anatomy associated with this plate should therefore leave the reader with knowledge of the variations in the branches of the subclavian artery concerned in our operative procedures, the complexity of the subclavian vein in its relation to the first rib and sternal end of the clavicle, and the proximity of the pleural dome which may be entered in securing the vascular supply and drainage of the upper limb

PLATE III

POSTERIOR RELATIONS OF THE SHOULDER GIRDLE

The relations of the shoulder girdle to the trunk posteriorly are much less complicated than those we have observed anteriorly The important neurovascular channels are found on the anterior aspect, and muscular branches only will be sectioned posteriorly in the operative procedures, whether in the final posterior dissection of the forequarter amputation performed from the anterior aspect, in the first stage of the same operation executed from behind, or in the operations of partial or total scapulectomy or interscapulo-thoracic resections

In Figure A the basic musculoskeletal structures

on which the scapula rests will be seen The serratus posterior superior arising from the spines of cervical 6, 7 and thoracic 1 is seen extending as a thin, aponeurotic sheet to insert at the angles of the second to fifth ribs It covers the deep paravertebral muscles of the cervico-dorsal region, *i e* splenius capitis, splenius cervicis, and iliocostalis cervicis Just anterior to the last muscle is the posterior member of the scalene group, the scalenus posterior

The only major vessels which will be encountered, unless large anastomotic channels have developed, are the muscular branches to the trapezius and rhomboid muscles from the superficial cervical and descending scapular arteries These form a rich anastomosis with the vessels related to the scapula and its intrinsic muscles, the supraspinatus, infraspinatus, teres minor, teres major, and the subscapularis (*see also* Fig 14) These anastomoses achieve great surgical importance in large neoplasms involving the scapula itself or its intrinsic muscles

The scapula with its musculature is applied in Figure B The spine rests at the level of the third rib and the lower angle is opposed to costa VII The levator anguli scapulæ is added and we note that the transverse cervical vessels and the spinal accessory nerve (cranial XI) pass over its surface before entering the deep surface of the trapezius and the substance of the rhomboids At the superior angle of the scapula the first digitation of the serratus anterior can be seen in close proximity to the origin of the supraspinatus Figure B therefore illustrates the deep plane of muscles which must be sectioned to free the scapula posteriorly, *i e* from above downwards, the levator anguli scapulæ and the rhomboids minor and major

The large flat superficial muscles are added in Figure C Note the extensive origin of the trapezius from the base of the skull to thoracic 12 Its origin and insertion are best considered in three parts The origin from the base of the skull with its insertion on the outer third of the clavicle can be considered the *superior portion* This clavicular insertion can be subperiosteally resected in all the procedures under discussion The *medial portion* arises from the cervical and upper thoracic spinous processes It is largely aponeurotic in nature in the vertebral area and extends transversely to insert on the spine of the scapula intimately fused with the deltoid origin The *inferior portion* of the trapezius ascends from its origin on the dorsal spinous processes as low as thoracic 12 It covers the upper half of the vertebral border of the scapula and forms a tendinous insertion on a tubercle at the base of the spinous process It will be seen that this complete sheet can be subperiosteally detached from the scapula and clavicle when required or sectioned through its substance (*see* Plate X)

The second large muscle is the latissimus dorsi, which crosses and attaches itself to the lower angle of the scapula before passing to its insertion on the humerus in intimate relationship to the teres major These two muscles form the posterior boundary of the axilla The latissimus dorsi must be detached from the inferior angle of the scapula and transected just beyond this point to free the scapula in ablations of this bone

The third and final muscle for consideration is the deltoid Its origin from the spine of the scapula, as likewise from the acromion and clavicle, can well be resected subperiosteally when necessary However, in the forequarter amputation, whether performed from the anterior or the posterior aspect, it is only the trapezius and latissimus dorsi muscles which must be transected together with the deeper group described above, *i e* the levator scapulæ and rhomboids minor and major Once these two groups are divided the scapula will wing forwards permitting section of the serratus anterior, the final bond holding the scapula to the trunk on the posterior aspect (*see also* Plate X)

PLATE IV

THE LYMPHATIC SYSTEM IN RELATION TO THE FOREQUARTER AMPUTATION

The forequarter amputation may be indicated in cases of carcinoma and melanosarcoma involving the upper limb and shoulder region, and also in certain cases of brachial lymphœdema with intractable pain associated with carcinoma of the breast For this reason an understanding of the lymphatic glands and channels is valuable The basic pattern is illustrated in diagrammatic fashion on this plate, where the main groups of glands are shown in the principal drawing while the collecting channels with their confluence with the venous system are represented in the smaller diagram Reference to detailed studies of the lymphatic system will reveal the great variability in the number and size of the glands of the different groups and of their collecting channels Similarly the terminal arrangements of the lymphatic ducts and channels show many variations Meticulous detail in this connection is not deemed necessary in this presentation, but such detail can be obtained by recourse to the appended references [45, 94, 98]

In the upper drawing the junction of the lymphatic and venous systems is shown This takes place where the subclavian and internal jugular veins unite to form the innominate vein It will be noted that the thoracic duct, which constitutes the main drainage of the lower part of the body, empties on the left side The lymphatic channels for each upper limb unite to form the subclavian trunk while those from the head and neck on each side produce the jugular trunk Various channels arise in the thoracic cavity, but the principal channels are the right and left bronchomediastinal trunks The internal mammary channels draining the internal mammary chains of glands are important in the spread of carcinoma of the breast

The lower drawing shows that the lymphatic drainage of the upper limb follows the blood-vessels and converges on the axilla The lateral, central, infraclavicular, and apical glands provide filters before the neoplastic cells can enter the venous circulation It can be readily perceived that once the apical glands are involved, venous dissemination of neoplastic cells is imminent

The lymphatic spread of carcinoma of the breast can be understood from this illustration Here again the main drainage is to the axillary glands, first the pectoral and subscapular groups, thence to the central and apical glands and finally to the subclavian trunk The drainage of the medial sectors of the breast is also to the internal mammary chain of glands which is part of a rapid and direct communication with the venous system through the internal mammary trunk

The reader should note the external jugular anterior jugular, inferior deep cervical, spinal accessory, and transverse cervical chains They may require block dissection when the forequarter amputation is performed in cases of melanosarcoma

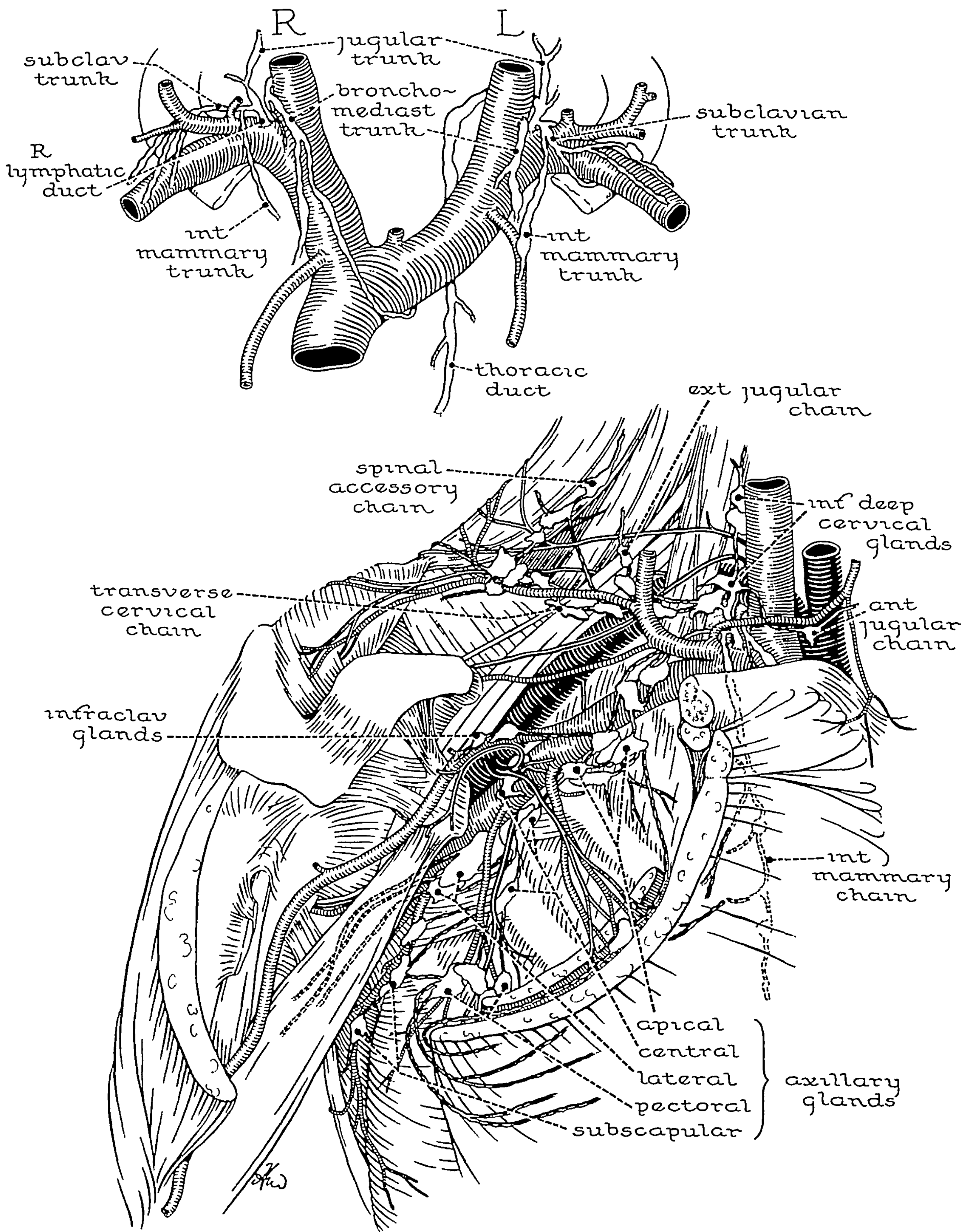

R
L
jugular trunk
subclav trunk
broncho-mediast trunk
subclavian trunk
R lymphatic duct
int mammary trunk
int mammary trunk
thoracic duct
ext jugular chain
spinal accessory chain
int deep cervical glands
transverse cervical chain
ant jugular chain
infraclav glands
int mammary chain
apical
central
lateral
pectoral
subscapular
axillary glands

PLATE IV

III
Indications

General Considerations

THE complete removal of the upper limb with the shoulder girdle is a grossly deforming and disabling operative procedure and the patient usually recoils in horror when it is suggested This instinctive reaction delays the definitive treatment and valuable time is lost In some cases the patient refuses to accept the loss of limb and the surgeon may substitute local excision, scapulectomy, or the interscapulo-thoracic resection which is second best The responsible surgeon has therefore a difficult task to make the correct decision and to influence the patient and relatives to accept this advice when given In present-day hospital practice great benefit accrues from presenting such unusual cases before the general staff for discussion In this way the combined experience is pooled, and this should include the advice of pathologist and radiotherapist Such a course reassures both patient and surgeon and leads to mutual confidence and peace of mind

Statistical studies have shown that in the carefully selected case *primary forequarter amputation* affords a greater freedom from recurrence and superior survival results when compared with *secondary forequarter amputation* performed after initial local excision of the tumour resection of the upper end of the humerus scapulectomy, amputation through the upper arm, or disarticulation at the shoulder Therefore, when indicated, the earliest possible primary forequarter amputation is the ideal It is regrettable that a large percentage of the present-day amputations is being performed for palliative purposes and as a last resort after all other procedures have failed

The patient should be assured that this major operation can be safely executed with the benefits of present day anaesthesia and transfusion service All cases should receive a complete pre-operative evaluation to exclude extension of the growth to other areas such as the lungs, which would generally preclude the radical treatment of the primary growth

Specific Indications

Generally speaking, the forequarter amputation is indicated for certain primary lesions produced by trauma, infection, or neoplasm or the sequelæ of such processes In the present era the most common group of cases is associated with malignant disease

Trauma (*see* Chapter VII)

Trauma in its various forms has been responsible for many cases of forequarter amputation, some of which are recorded in the medical literature[110, 172]

In civilian life the most common cause has been entanglement of the limb in machinery Avulsions of the limb at the girdle may be *complete*, and when this occurs the result is similar to the case of Wood previously mentioned The major arteries develop spasm and the blood loss and shock are frequently not excessive Some avulsions may be *partial*, and the patient is brought to hospital where the decision to preserve or ablate the limb must be made In this connection the deciding factors are the viability and future usefulness of the limb If the brachial plexus has been avulsed, restoration of associated disrupted major vessels by operative means will not be justifiable Similar considerations must be given by the surgeon in the evaluation of cases presenting after *gunshot wounds, automotive and other transport accidents*, and the *wounds inflicted by savage animals*

Extensive burns of thermal, electrical or chemical nature must be similarly evaluated Often the time interval will be the determining factor A conservative and expectant attitude is often best when the case is seen at an early stage, but in the later stages where the life of the patient is threatened a definitive course must be adopted The author has seen one case of severe electric burn with gangrene of the upper limb where a forequarter amputation might have been life saving

Infection

There are few indications to-day where infection by itself would justify these major procedures Early treatment with the antibiotic agents has removed this problem The older literature contains reference to such procedures for extensive pyogenic and tuberculous osteomyelitis involving the shoulder girdle and threatening the life of the patient Some surgeons will recall a well-known colleague who underwent scapulectomy for typhoid osteitis of this bone prior to the antibiotic era

Neoplasms

Three groups of malignant growths may necessitate the forequarter ablation

1 Carcinoma and melanoma of the upper limb with axillary metastases Certain cases of carcinoma of the breast with gross lymphœdema and pain in the upper limb
2 Sarcomata of the soft tissues of the shoulder region

TABLE I

Histologic Type of Tumour	*Interscapulo-thoracic Amputation*			
	No		*Per cent*	
Total cases		**88**		**100·0**
Tumours of skin, primary in the extremity		**26**		**29 5**
Melanoma	20		22 7	
Carcinoma	6		6 8	
Tumours of skin, primary elsewhere		**7**		**8·0**
Melanoma	2		2 2	
Carcinoma	5		5 7	
Tumours of soft somatic tissues, primary in the extremity		**47**		**53·4**
Rhabdomyosarcoma	14		15 9	
Fibrosarcoma	8		9 1	
Synovioma	7		8 0	
Sarcoma unclassified	6		6 8	
Malignant neurilemoma	5		5 7	
Angiosarcoma	4		4 5	
Liposarcoma	1		1 1	
Reticulum cell sarcoma	1		1 1	
Dermatofibrosarcoma protuberans	0		0 0	
Kaposi's sarcoma	0		0 0	
Extraosseous osteogenic sarcoma	0		0 0	
Alveolar soft-tissue sarcoma	0		0 0	
Extra-abdominal desmoid	1		1 1	
Tumours of bone primary in the extremity		**8**		**9·1**
Osteogenic sarcoma	3		3 4	
Chondrosarcoma	2		2 3	
Endothelial myeloma	1		1 1	
Periosteal fibrosarcoma	0		0 0	
Neuroblastoma	1		1 1	
Reticulum cell sarcoma	1		1 1	

(*By courtesy of Dr G T Pack and the Journal of Bone and Joint Surgery*)

3 Sarcomata of the bones of the shoulder girdle

The above are listed in accordance with the frequency of their occurrence, but this major operation has been performed more frequently for sarcomata of the soft tissues than for carcinomata and melanomata, and least frequently for sarcomata involving the upper end of the humerus, scapula, or clavicle

The histologic type of tumour can best be realised by reference to Dr Pack's table of eighty-eight cases which is the largest and best documented series in the surgical literature

Malignant Disease of the Skin

Patients with malignant disease arising in the skin of the upper limb form a group of increasing size Of these, carcinoma arising in the peripheral part with lymphatic spread to the axillary glands constitutes a surgical problem which can only be cured by forequarter amputation (*see* Figs 22 and 23) This is true of epithelioma developing in radiodermatitis of the hands or in thermal burns in which the carcinoma has spread proximally Certain cases of melanoma of the upper limb and shoulder region with axillary lymphatic involvement are also candidates for this major procedure, with associated block dissection of the cervical nodes when indicated

Some surgeons have ablated the limb and girdle as a palliative procedure in cases where radical amputation for carcinoma of the breast has been followed by gross lymphœdema of the limb and intractable pain from involvement of the brachial plexus by carcinomatous infiltration

Scapulectomy has been successfully performed for radionecrosis of this bone with extensive sinus formation following radiation for overlying epithelioma The operation has afforded relief from intractable pain and long-term survival is recorded

Sarcoma of the Soft Tissues

The various types of soft tissue sarcomata are recorded in the table Most cases are best treated by the forequarter operation, and local excision and scapulectomy should be avoided as they give inferior results Pre-operative and post-operative radiation must be considered and have an important place in the treatment of certain types of sarcoma

Sarcomata of Bone

Although sarcomata of the upper end of the humerus and scapula treated by the forequarter amputation do not present any five-year survivals in Dr Pack's series, the freedom from local recurrence and length of survival is highest with the major procedures (*see* Fig 21) Previous local operations increase the local recurrence rate and lessen the time of survival Scapulectomy affords little hope in the sarcomata arising in this bone, with the exception of chondrosarcoma especially of secondary development Scapulectomy has also a place for large chondromata arising in connection with the scapula

Scapulectomy in association with irradiation constitutes the treatment of aneurysmal bone cysts and hæmangiomata arising in the scapula (*see* Fig 25).

IV

Operative Procedures

Pre-operative Considerations

AN operation of this magnitude requires considerable planning and attention to detail to ensure a successful result As in all operations, each case must be individually evaluated and special consideration given to the predominant variants of the case under treatment

Routine factors include the following

1 Attention to the haematological and electrolytic status of the patient Pre-operative transfusions may be required to bring the blood hæmoglobin to the range of 80 per cent Blood (1500 - 2500 ml) should be available during the operation and possibly in the post-operative period The blood loss during the operation in the average case can be judged from the following case record

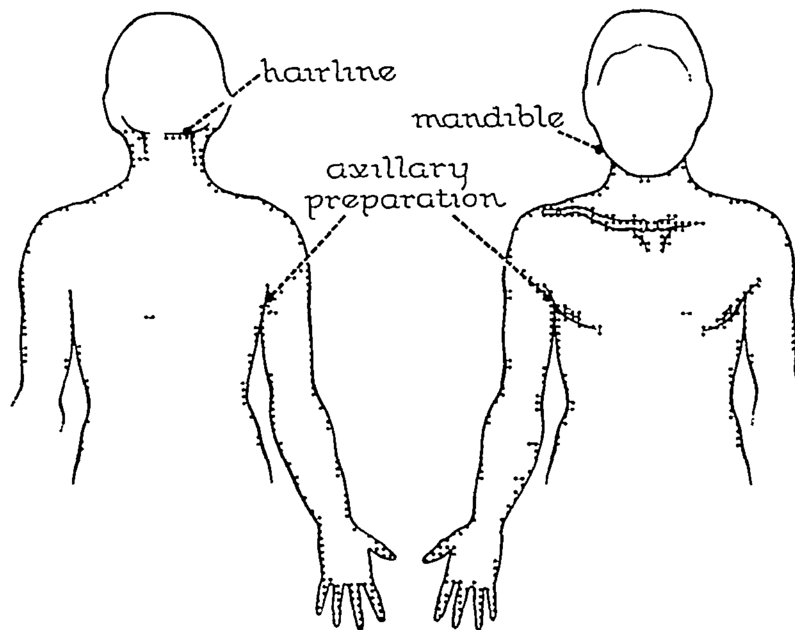


FIG 7

Area of skin preparation for major operative procedures involving the shoulder girdle

The skin preparation for the forequarter amputation interscapulo-thoracic resection or scapulectomy should be extensive and include, both anteriorly and posteriorly, the whole neck and trunk to the iliac crests, the whole of the upper extremity including the hand on the affected side and to just above the elbow on the opposite side Careful shaving and meticulous preparation of the axilla is required on the side of the ablation

Blood Loss Study (*courtesy Dr Paul Weil*)

This record demonstrates the amount of blood lost in the average forequarter amputation The determination may be made *directly* by calculating the loss from increase in weight of the sponges during operation, or *indirectly* by measuring the blood volume by using

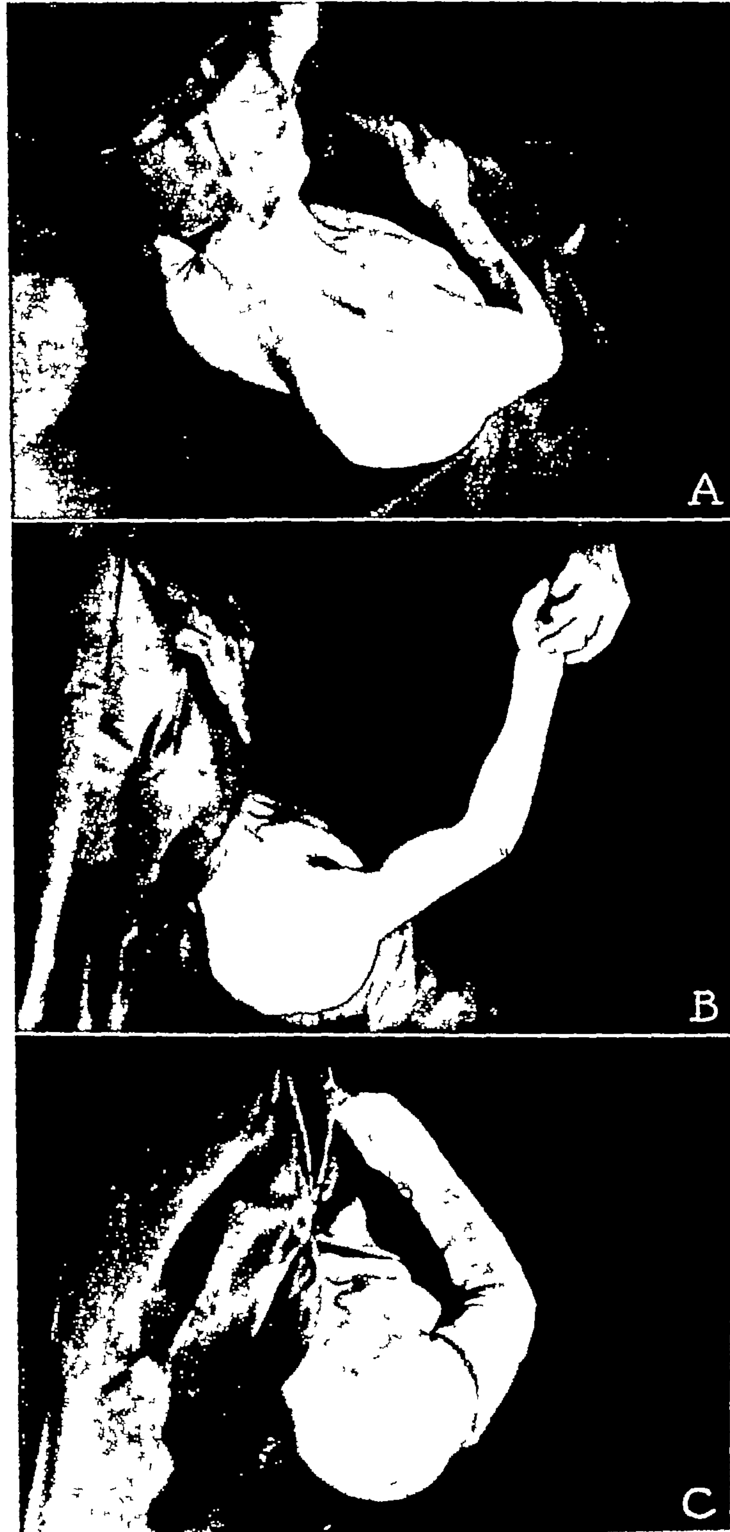


FIG 8

Posturing and draping for the forequarter amputation performed from the anterior aspect

A The patient is postured in the semi-supine position As the patient will receive the anæsthetic by intubation a low anæsthetic screen is used closing off the anæsthetic apparatus from the operative field

B The limb is held clear of the sterile towels by an orderly while the operative field is framed by the towels

C The hand has been received into a sterile towel and the whole upper limb then enclosed in stockinet to be free for manipulation during the operation

Note that the whole extent of the clavicle and the whole extent of the scapula are exposed to the surgeon Tilting of the operating table can facilitate the surgical procedure

FIG 8

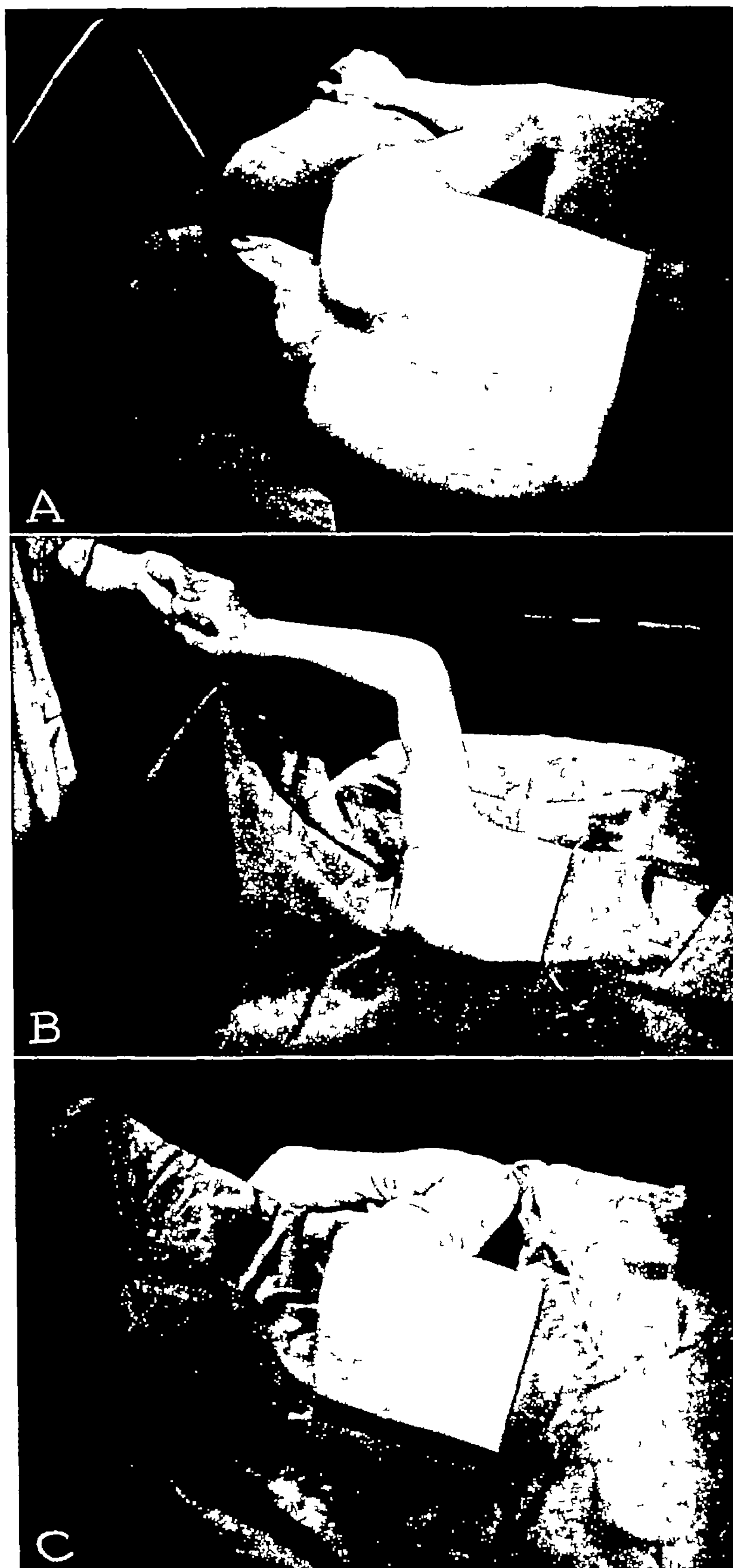


FIG 9

FIG 9

Posturing and draping for the forequarter amputation performed from the posterior aspect and for scapulectomy

A The patient is postured in the left lateral position The anæsthetic screen is in place

B An orderly supports the upper limb by the hand while the foundation draping is arranged

C The hand is received into a sterile towel and the whole upper limb enclosed in stockinet so as to be free for manipulation A laparotomy sheet is used as a coverall and its opening frames the field of operation Again, the table can be tilted and the limb manipulated when the surgeon passes to the anterior aspect for the anterior dissection in the forequarter operation

radioactive iodinated human serum albumin (R I H S A method) The calculations in the present case, made by the indirect method, are

	Pre-operative	*Post-operative*
Plasma volume	2440 ml	2110 ml
Red cell mass	1640 ,,	1250 ,
Total blood volume	4080 .	3360 ,,

Assuming the amputated arm contained approximately 300 ml of blood the blood volume deficit at the end of the operation was no more than that contained in a bottle of blood (420 ml)

The amount of blood lost measured 1300 ml Consequently three bottles of blood each containing 500 ml were administered Both clinically as judged by maintenance of normal blood pressure and pulse, and as shown by blood volume studies, tabulated above, the amount of blood transfused was sufficient to prevent shock from a reduced blood volume

At a subsequent operation (resection of a carcinomatous nodule in the scar) during which neither method was used and no transfusions given, the patient developed post-operative shock An infusion of lævophed and a transfusion of blood were required to restore the blood pressure

2 Meticulous pre-operative skin preparation of the operative field (Fig 7)

3 General anæsthesia with intubation A careful recording of the blood pressure throughout the operation is routine

4 Attention to correct posturing and draping to facilitate the operative procedure (Figs 8 and 9) Antibiotic coverage

OPERATION FROM THE ANTERIOR ASPECT

PLATE V

LINES OF INCISION EXPOSURE AND RESECTION OF BODY OF CLAVICLE[12]

Figure A illustrates a diagrammatic cross section through the right side of the chest and shoulder girdle at the level of the second rib The heavy black line and arrows indicate the sites of muscular section and the plane of fascial separation which have been found most useful for the interscapulo-thoracic ablation of the shoulder girdle in continuity with the upper limb

The anterior muscular section traverses the pectorales major and minor to the plane of the thoracic cage covered by the serratus anterior With transection of the clavicle and its related soft tissues the girdle falls away from the chest wall, and severance posteriorly of the muscles attached to the vertebral border of the scapula *i e*, the trapezius, rhomboids and serratus anterior, completes the detachment of the girdle in the horizontal plane

In Figure B the lines of incision are indicated These must be varied when necessitated by the presence of a large neoplasm Two incisions and skin flaps are depicted:

1 Superoposterior, and
2 Anteroinferior

The operator will usually make his first incision (*a* - *b*) the length of the clavicle The posterior limb (*b* - *c*) will be delayed until the posterior dissection begins From (*a*) of the primary incision, the antero-inferior incision runs in racquet fashion to the anterior border of the axilla (*c*) Again the completion of the anterior incision (*c* - *c'*) is delayed until the posterior limb (*b* - *c'*) of the superoposterior flap and severance of the posterior musculature are made

Figure C shows the body of the clavicle exposed after incision of the periosteum along its length A vein of variable size joining the cephalic and external jugular systems, as illustrated here, will sometimes be encountered The sites of section of the clavicle for the classic Berger operation[10 11] are shown After section at (1) with the circular or Gigli saw, the lateral cut end is retracted anterolaterally with a bone hook or forceps and sectioned at (2) If the complete sternal end must be removed, one finds it technically easier to make this resection of the body before proceeding with this additional dissection

In Figure D the heavy dotted line shows where the pectoralis major should be sectioned to expose the costocoracoid membrane This exposure will assist the surgeon in finding the plane and visualising the axillary vessels and infraclavicular portion of the brachial plexus

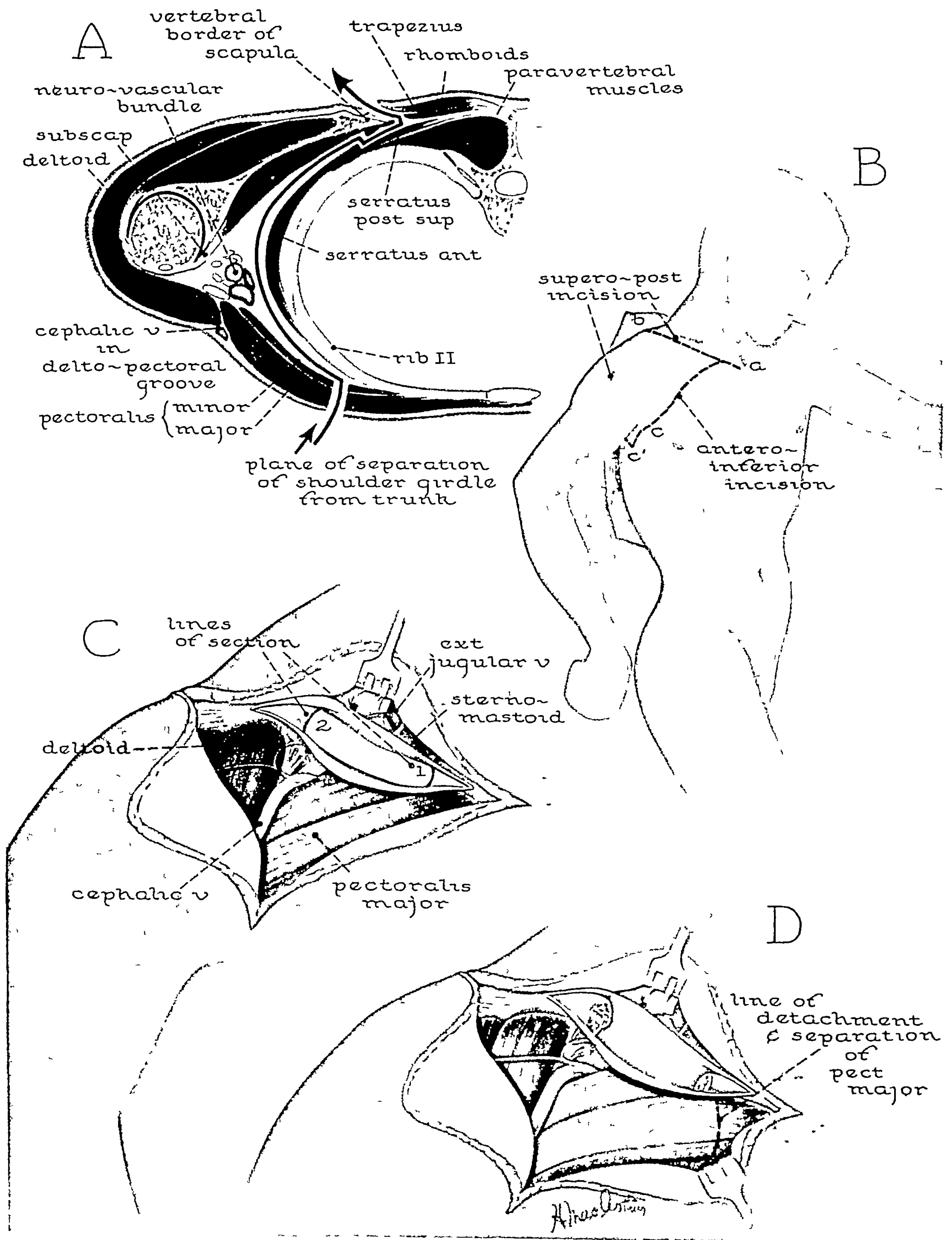

A
vertebral border of scapula
trapezius
rhomboids
paravertebral muscles
neuro-vascular bundle
subscap
deltoid
serratus post sup
serratus ant
cephalic v in delto-pectoral groove
rib II
pectoralis {minor major
plane of separation of shoulder girdle from trunk
B
supero-post incision
b
a
c
c'
antero-inferior incision
C
lines of section
ext jugular v
sterno-mastoid
deltoid
2
1
cephalic v
pectoralis major
D
line of detachment & separation of pect major

Plate V

PLATE VI

EXPOSURE OF THE SUBCLAVIAN VESSELS

The five drawings on this plate continue the operation from the anterior aspect and illustrate the exposure of the subclavian vessels. The viewer should note that the plane of the major vessels can be found by approaching from either above or below the clavicular bed.

In Figure A the general topography of the region is shown. The body of the clavicle has been removed, and for diagrammatic purposes the superficial layer of the musculature formed by the pectoralis major, deltoid, sternomastoid, and trapezius has been omitted.

The second layer of musculature and fascia includes the omohyoid, its related fascia, the subclavius, costocoracoid membrane and pectoralis minor. Superficial to this layer and passing through it to join the subclavian and axillary veins are major venous radicals of the external jugular, anterior jugular, and cephalic systems. These require meticulous attention at operation to prevent major blood loss. The scalenus anterior is an important landmark in this operation. It is covered by a layer of fibro-fatty tissue called the scalene fat pad which is easily pushed aside or teased apart by blunt dissection. The phrenic nerve on the scalenus anterior is digitally palpable.

In Figure B a window has been cut in the omohyoid fascia to expose the subclavian vein as it lies on the tendinous insertion of the scalenus anterior and first rib. Observe the relation of the tendinous intersection of the two bellies of the omohyoid to the scalenus anterior and the subclavian vein. It is sometimes useful to dissect through the omohyoid fascia by following the external jugular vein to its communication with the subclavian vein.

In Figure C the window has been made in the costocoracoid membrane and the axillary vessels exposed. The lateral anterior thoracic nerve supplying the pectoralis major has been found useful in this exposure and can be followed through the fascia to the lateral side of the axillary artery. A Kocher dissector has been passed upwards in the plane anterior to the vessels and is seen to appear above the omohyoid muscle. Note that its tip lies just superficial to the third part of the subclavian artery and the brachial plexus. The tissues superficial to this dissector must be severed to give the wide exposure of the subclavian vessels which is desirable. This is best accomplished by piecemeal isolation and severance of these tissues. This inferior approach has been found easier than that through the omohyoid fascia and has been recommended by authors such as Le Conte[64, 65] and Kocher[61].

In Figure D the arrows depict these two approaches as illustrated in the sagittal plane: (*a*) through the omohyoid fascia; (*b*) through the costocoracoid membrane.

The lightly shaded area denotes the tissues finally transected to give the general exposure of the vessels which can be studied in Figure E. In this final drawing of the plate the sternomastoid and trapezius above the clavicle and the deltoid and pectoralis major below the clavicle are represented *in situ*. The pectoralis major has been partially reflected to facilitate the exposure. (Review Figure D of the preceding plate.)

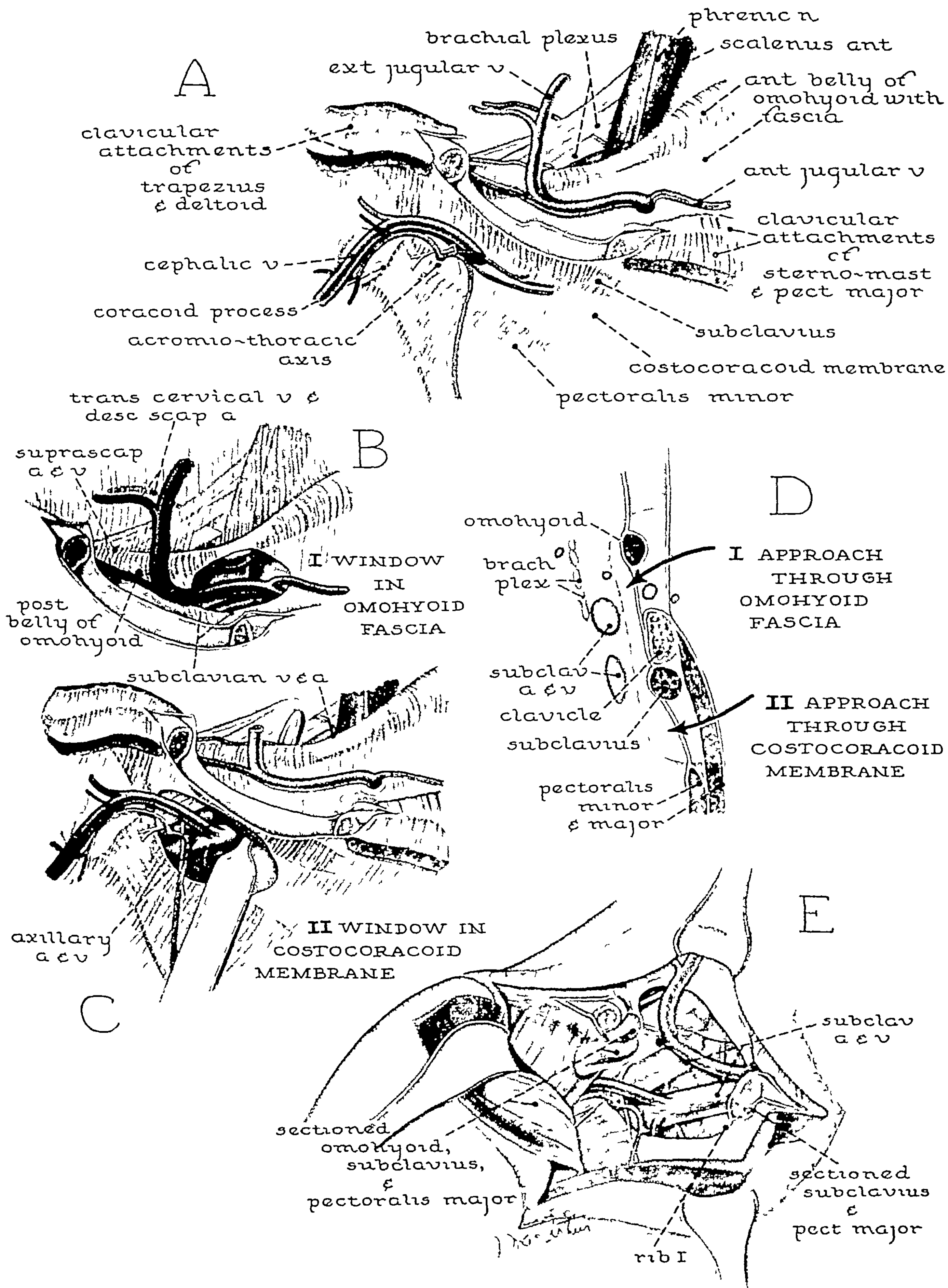

A
phrenic n
brachial plexus
scalenus ant
ext jugular v
ant belly of omohyoid with fascia
clavicular attachments of trapezius & deltoid
ant jugular v
clavicular attachments of sterno-mast & pect major
cephalic v
coracoid process
subclavius
acromio-thoracic axis
costocoracoid membrane
pectoralis minor
B
trans cervical v & desc scap a
suprascap a & v
I WINDOW IN OMOHYOID FASCIA
post belly of omohyoid
subclavian v & a
D
omohyoid
brach plex
I APPROACH THROUGH OMOHYOID FASCIA
subclav a & v
clavicle
subclavius
II APPROACH THROUGH COSTOCORACOID MEMBRANE
pectoralis minor & major
axillary a & v
II WINDOW IN COSTOCORACOID MEMBRANE
C
E
subclav a & v
sectioned omohyoid, subclavius, & pectoralis major
sectioned subclavius & pect major
rib I

PLATE VI

Plate VII

COMPLETION OF THE ANTERIOR DISSECTION

The drawings on this plate detail the ligation of the subclavian artery followed by that of the subclavian vein. Some surgeons elevate the limb to drain the blood into the general circulation before the vein is tied, but in cases of sarcoma many prefer to avoid this step for fear of possible dissemination of tumour cells.

In Figure A the external jugular vein is seen ligated and divided near its entry into the subclavian vein adjacent to the first rib. As previously stated, the final exposure of the subclavian vessels by division of the second layer of muscles and fascia is usually accompanied by ligation of these venous communications, as also by section of the suprascapular artery and vein which run in this fascial layer.

It is usual to ligate first the artery, and this is secured in its third part just distal to the scalenus anterior. It is encircled and ligated in two places with strong silk, divided between, and the proximal end transfixed and tied with a third strong silk ligature as shown in Figures B and C. Note again how the lateral anterior thoracic nerve may be used as a guide to the artery.

In published reports some surgeons have found difficulty in locating the third part of the subclavian artery. They prefer to expose the axillary artery by section of the pectoral muscles as suggested by Kocher. The first part of the axillary artery can be ligated or it can be utilised to guide the plane of dissection to the third portion of the subclavian artery [illegible].

Figure C shows the same technique employed for the subclavian vein. In this drawing the sternal end of the clavicle remains in situ as in the classic operation described by Berger. Le Conte and others recommend the removal of the sternal end of the clavicle, and this is advisable in cases of lymphatic involvement from carcinomata arising in the skin of the extremity or in the breast where the most radical removal of lymphatic tissues is contemplated. Most complications in the past have arisen during the ligation of the subclavian vein. These have been fatal hæmorrhage and air embolism. Such problems can be avoided by recognising the presence of a thin, dense fascia fixing the vein to the first rib and to the lateral and posterior aspects of the rhomboid (costoclavicular) ligament. A further factor to remember is the thin and friable wall of the vein. Slow and painstaking isolation of the vein especially on its posterior and inferior aspects is therefore required. Ligation and transfixion is then accomplished in the same manner as for the artery.

In Figure D the line for division of the brachial plexus is indicated. Some surgeons prefer to inject procaine hydrochloride into each nerve root before division; others add the injection of absolute alcohol; yet others ligate each root proximally with fine silk. None of these procedures would appear to the author to afford a proven advantage. The line of division of the pectoral muscles is also shown. This will be varied with the lesion under treatment. It is best accomplished, as in radical amputation of the breast, by passing the index finger under the inferior border of the muscle, followed by division first of the pectoralis major and then of the pectoralis minor. This step will complete the anterior dissection with the exception of the anterior portion of the axillary tissues, which remains for final section after the posterior dissection is completed.

Figure E illustrates the operation at the completion of the anterior dissection.

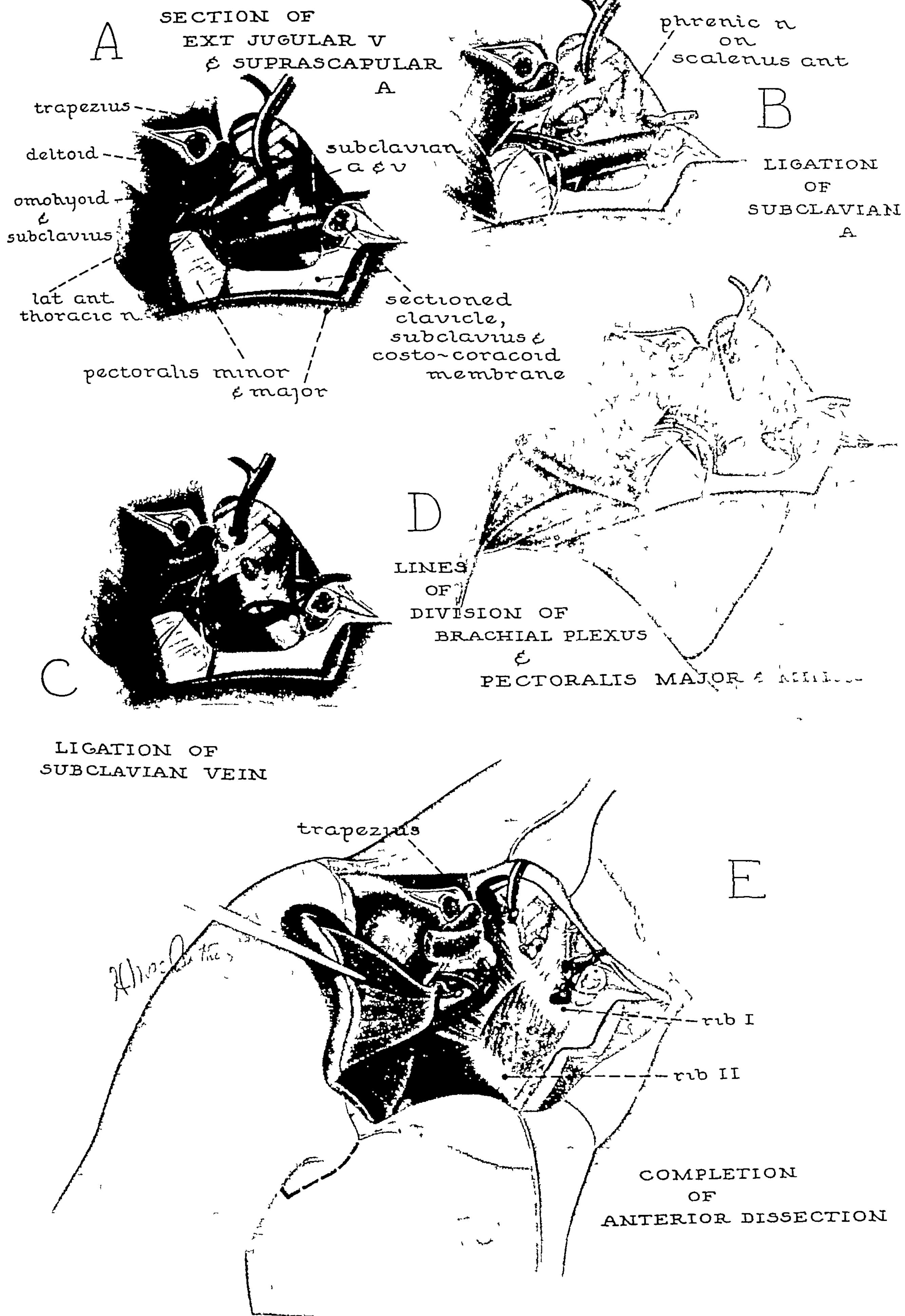

A
SECTION OF
EXT JUGULAR V
& SUPRASCAPULAR
A
trapezius
deltoid
omohyoid
& subclavius
subclavian
a & v
lat ant
thoracic n.
sectioned
clavicle,
subclavius &
costo-coracoid
membrane
pectoralis minor
& major
B
phrenic n
on
scalenus ant
LIGATION
OF
SUBCLAVIAN
A
C
LIGATION OF
SUBCLAVIAN VEIN
D
LINES
OF
DIVISION OF
BRACHIAL PLEXUS
&
PECTORALIS MAJOR
E
trapezius
rib I
rib II
COMPLETION
OF
ANTERIOR DISSECTION

PLATE VII

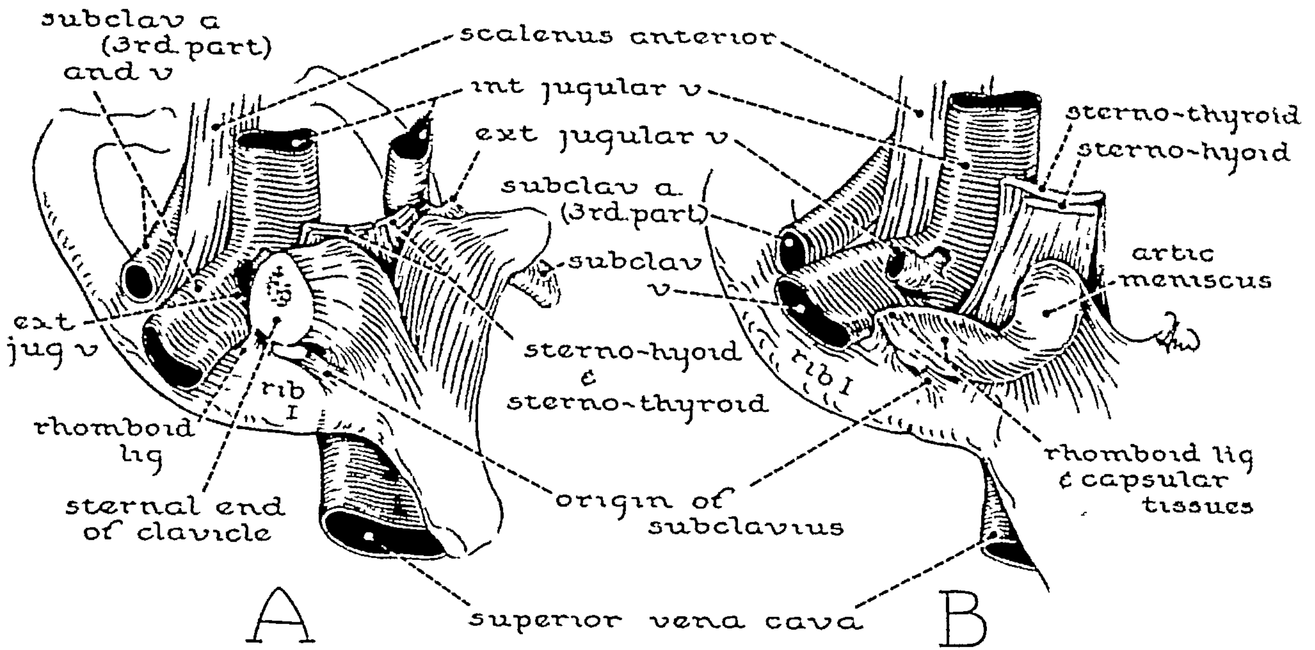


PLATE VIII

PLATE VIII

THE STERNAL END OF THE CLAVICLE

The detailed relations of the sternal end of the clavicle are visualised on this plate, a study of which will assist the surgeon should the operative procedure necessitate the total removal of the clavicle Further information can be obtained from other publications by the author [50, 51]

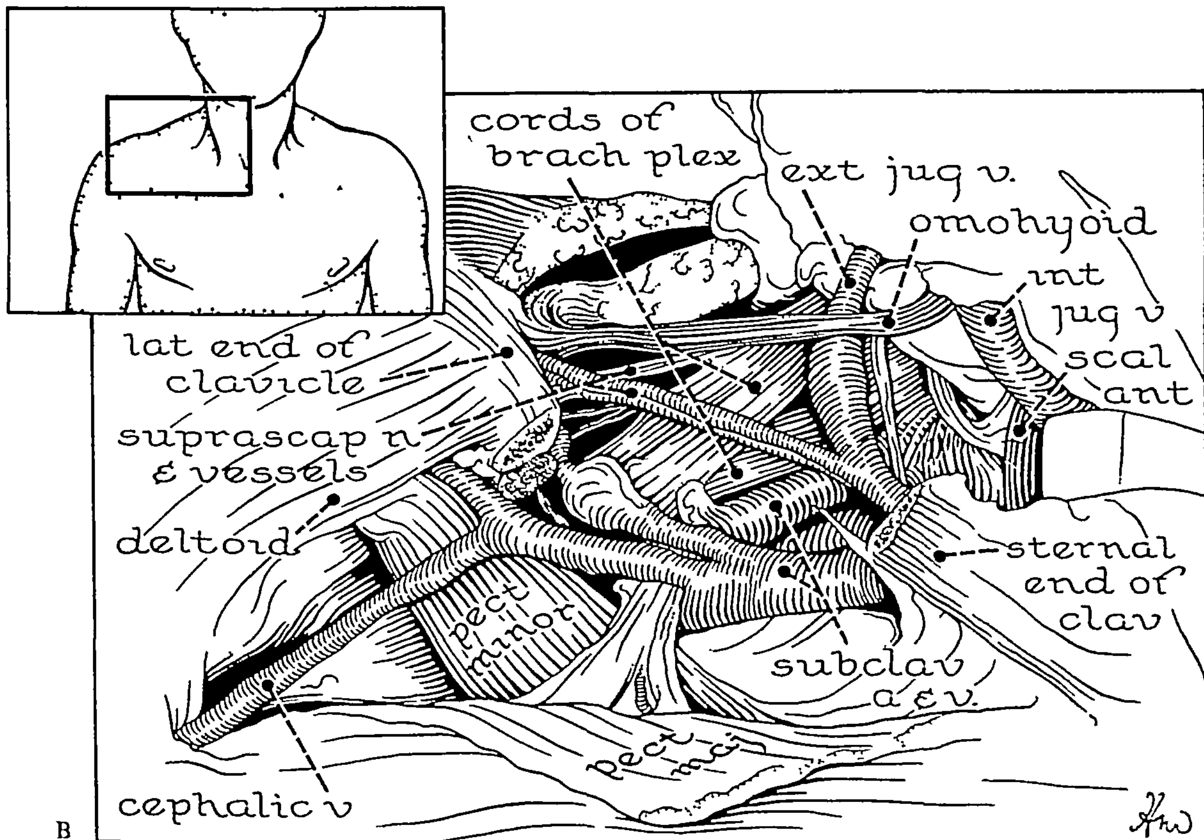
The most important structures to be considered are the large venous channels The subclavian vein, before its junction with the internal jugular vein, is closely adherent to the first rib and costoclavicular (rhomboid) ligament Other branches chiefly the large external jugular radical, empty into the subclavian vein in this area Some protection is afforded the large veins medially by the sternothyroid and sternohyoid muscles which serve as a buffer behind the sternal end of the clavicle

Removal of this portion of the bone in association with the forequarter amputation is especially indicated in cases of carcinoma with spread to the lymphatics at the base of the neck In these cases the most radical ablation of lymphatic tissue possible is desired The operator will best achieve the safe removal of the sternal end of the clavicle by dissecting directly on the bone and by cutting under direct vision Section of the soft tissues anteriorly superiorly and inferiorly should precede the final posterior dissection Most accidents will result in tears of the venous channels if forcible avulsion of this portion of the clavicle is attempted

Figures A and B show the appearances before and after removal of the sternal end of the clavicle depicted from oblique and directly anterior views respectively



A



B

Fig 10

The retro-clavicular structures from the anterior aspect Compare with Plates I II V VI VII and VIII

A Dissection showing the subclavian artery and vein and their tributaries together with the cords of the brachial plexus The middle third of the clavicle and the related fascia have been removed

B Diagrammatic key to the above dissection Note orientating inset

5

Plate IX

COMPLETION OF THE POSTERIOR DISSECTION

The three drawings on this plate illustrate the section of the muscles from the clavicle and scapula and the final section of the axillary tissues to complete the ablation of the girdle with the limb As the main blood supply has been secured hæmorrhage is not excessive, and ligation and division of the transverse cervical vein and the superficial cervical and descending scapular arteries will secure the important points of blood loss

The posterior limb of the superoposterior skin incision is made extending to the inferior angle of the scapula The flaps are dissected in the plane of the trapezius and the whole spine and vertebral border of the scapula exposed The second step is the separation of the trapezius from the outer third of the clavicle and spine of the scapula The finger can be inserted beneath this muscle layer and division rapidly completed with scissors (Figure A) As this step proceeds, an assistant using a hook or a finger can draw the outer end of the clavicle lateralwards and posteriorly, thus facilitating the operation Once the trapezius is separated, as shown in Figure B, the levator scapulæ and rhomboid minor and major are divided in quick succession near the vertebral border of the scapula If the superior angle of the scapula is lifted by the assistant away from the chest wall and the whole limb drawn forwards across the trunk, this step will be much easier Using the same technique, the insertion of the serratus anterior is next divided along its scapular attachment

The axillary portion of the skin incision joining the posterior and anterior dissections is now made The finger is placed beneath the latissimus dorsi, which is detached from the lower angle of the scapula and divided just anterior to this point The whole upper extremity can now be removed from the body, and the appearances are as seen in Figure C

The large muscles are approximated and fixed to the soft tissues of the chest wall as found best The skin wound is closed and dependent drainage arranged

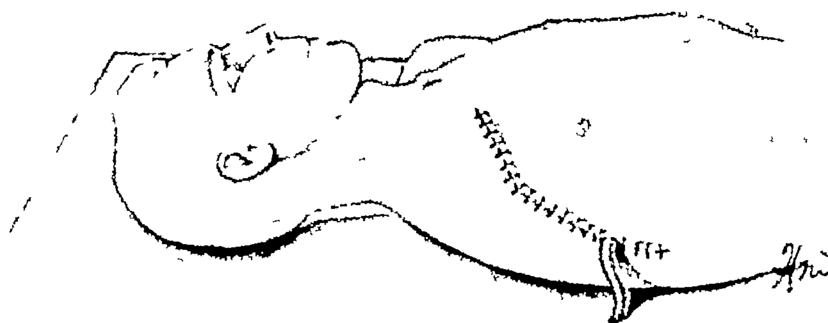


Fig 11
Closure of wound with dependent drainage A pressure dressing must be applied

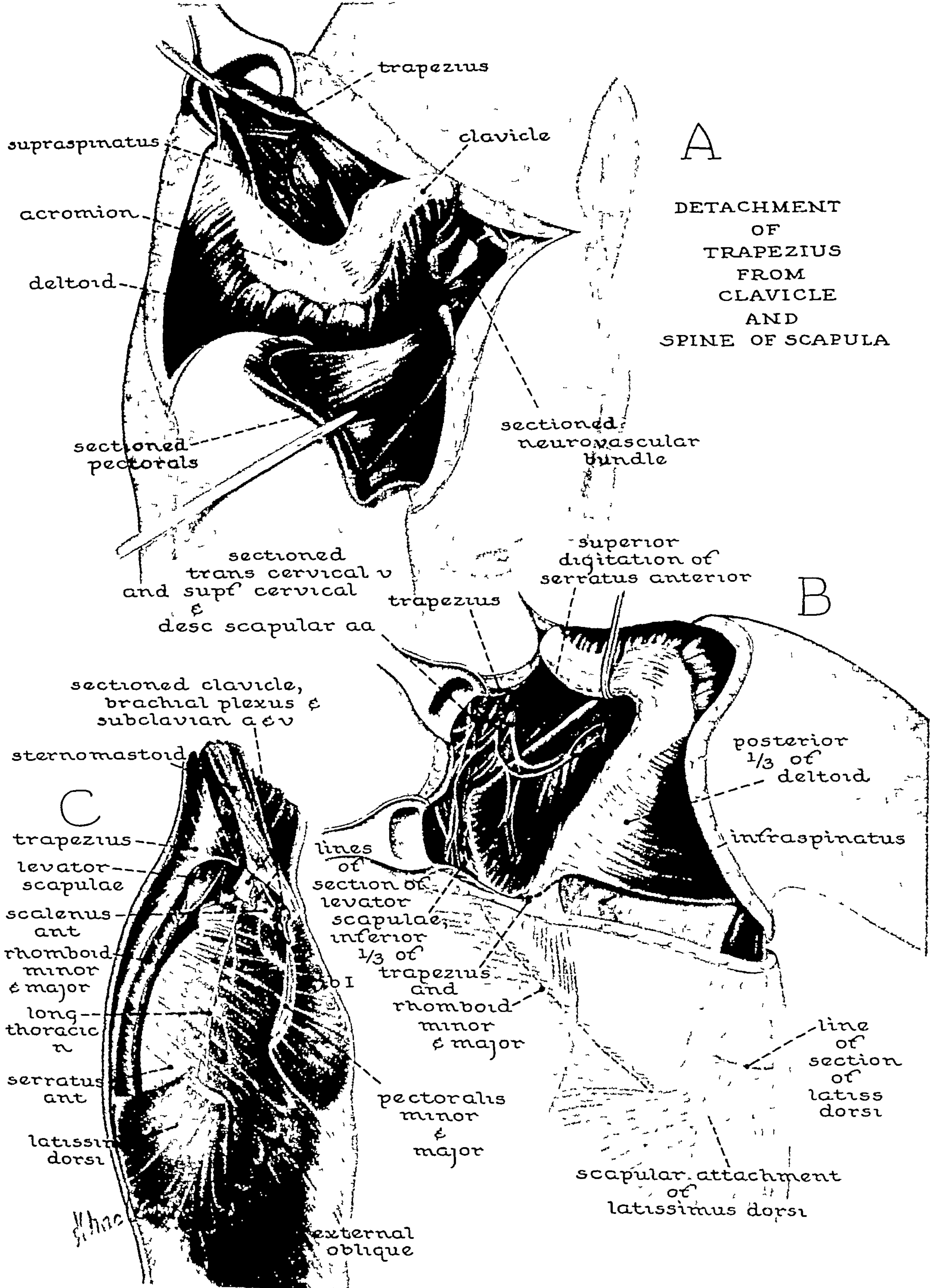

trapezius
supraspinatus
clavicle
A
DETACHMENT
OF
TRAPEZIUS
FROM
CLAVICLE
AND
SPINE OF SCAPULA
acromion
deltoid
sectioned pectorals
sectioned neurovascular bundle
sectioned trans cervical v and supf cervical & desc scapular aa
superior digitation of serratus anterior
trapezius
B
sectioned clavicle, brachial plexus & subclavian a & v
sternomastoid
C
posterior 1/3 of deltoid
trapezius
levator scapulae
infraspinatus
lines of section of levator scapulae, inferior 1/3 of trapezius and rhomboid minor & major
scalenus ant
rhomboid minor & major
long thoracic n
serratus ant
latissi dorsi
pectoralis minor & major
line of section of latiss dorsi
scapular attachment of latissimus dorsi
external oblique

Plate IX

OPERATION FROM THE POSTERIOR ASPECT

Plate X

THE FOREQUARTER AMPUTATION FROM THE POSTERIOR ASPECT (LITTLEWOOD'S TECHNIQUE)[46, 60, 71]

The forequarter amputation from the anterior aspect has been accepted, with varying modifications to suit the particular case, since the time of Berger Some surgeons had performed this major ablation from the posterior aspect but the publication of Littlewood[71] served to bring this technique into greater prominence In cases not requiring block dissection of the lymphatic glands at the base of the neck, there seems little doubt that the Littlewood technique can be performed more rapidly once the anatomical relationships are accurately understood However, it must never be forgotten that the subclavian artery and vein are at a considerable depth when the operation is performed from the posterior aspect, and if the clavicle is sectioned near its sternal end care must be taken when the limb is manipulated away from the trunk since the sectioned lateral end of the clavicle may easily puncture the venous wall

These two plates illustrating the Littlewood technique cover the steps of the posterior dissection up to the section of the cords of the brachial plexus and the ligation of the artery and vein These latter technical aspects together with the anterior dissection are identical with those for the operation from the anterior aspect and can readily be reviewed in Plates V, VI, VII and IX

Figure A shows the patient postured in the left lateral position for the operation on the right side The surgeon stands facing the back of the patient for the posterior dissection, passing to the opposite side for the anterior dissection and the final ablation of the extremity. The line of the superoposterior incision is depicted but may be altered to suit the particular circumstances of the individual case

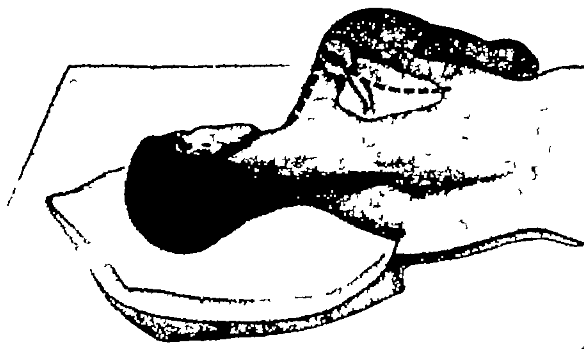
In Figure B the skin flaps have been undermined from the clavicle superiorly to the inferior angle of the scapula in the vertical direction and from the vertebral border of the scapula well across the fossæ of the scapula in the transverse direction Note especially the spine of the scapula with the attachment of the trapezius and also the posterior third of the deltoid This drawing illustrates the line of section of the trapezius which constitutes the more superficial layer of the related musculature. The trapezius can be separated at its attachment to the clavicle and spine of the scapula, or more rapidly still by placing the finger beneath it and cutting between clamps with scissors along the dotted line The viewer should also note in this drawing the teres major at the lower angle and the related latissimus dorsi with its scapular attachment This latter muscle will be separated and sectioned along the line indicated in the final step of the anterior dissection, but it is included here for completeness

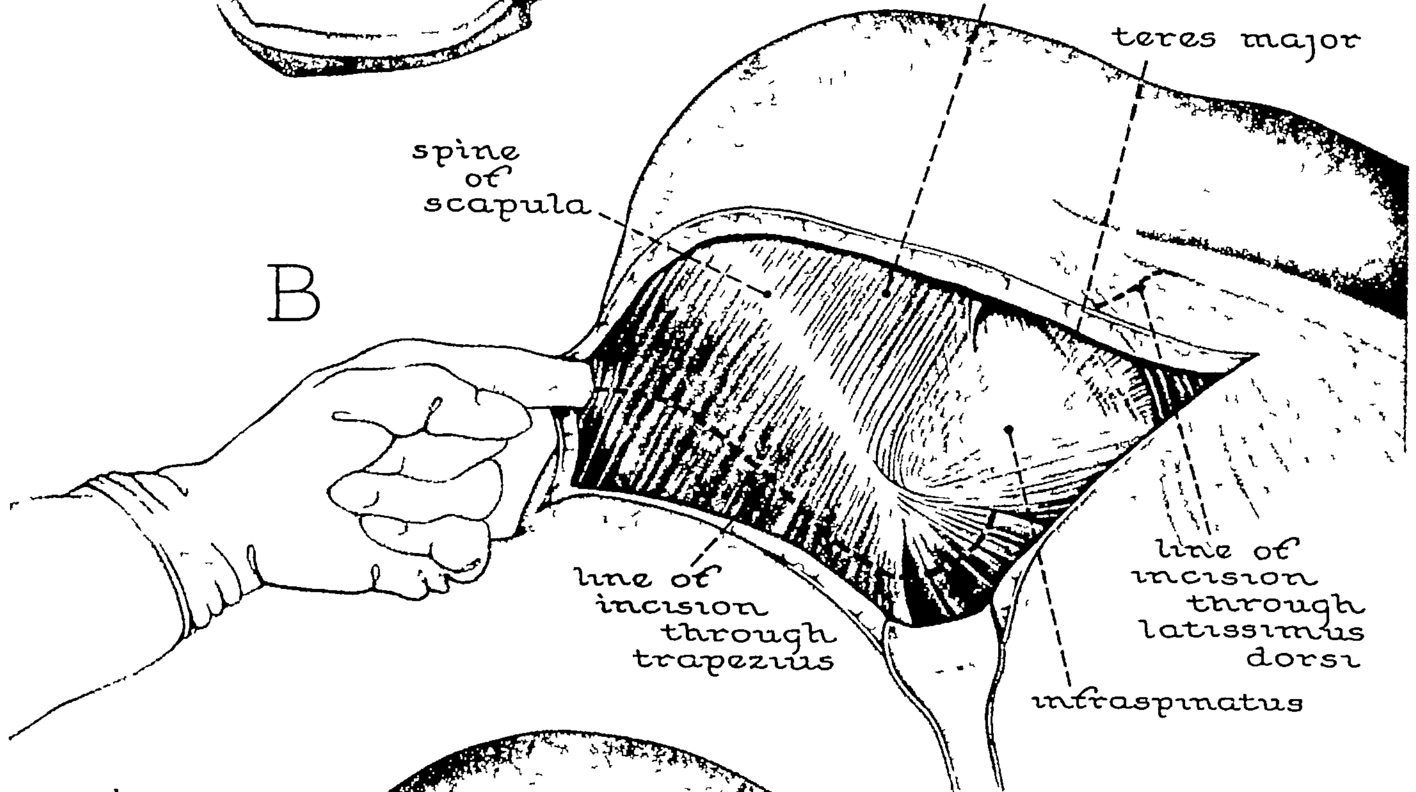
As shown in Figure C, after section of the trapezius, the deeper layer of the musculature attached to the superior angle and vertebral border of the scapula comes into view These muscles, the levator scapulæ and the rhomboids minor and major, are readily identified by drawing the scapula away from the chest wall with hook or retractor and passing the finger beneath this layer Section is performed rapidly with scissors

In the severance of these two layers of muscles, branches of the superficial cervical and the descending scapular vessels will be encountered and will require ligation The superior digitation of the serratus anterior will be severed close to the superior angle of the scapula as this bone is drawn away from the chest wall The remaining insertion of this muscle should be divided close to its attachment to the vertebral border to complete the posterior division of the muscles binding the scapula to the thoracic cage

In the superior part of the incision the neurovascular bundle will be found embedded in a bed of fibro-fatty tissue It is closely related to the superior digitation of the serratus anterior

A SUPERO~POSTERIOR INCISION





line of incision through superior digitation of serratus anterior
neuro-vascular bundle
supf cervical a
C
scapular attachment of latissimus dorsi
line of incision through levator scapulae & rhomboid minor & major
H. MacArthur

PLATE X

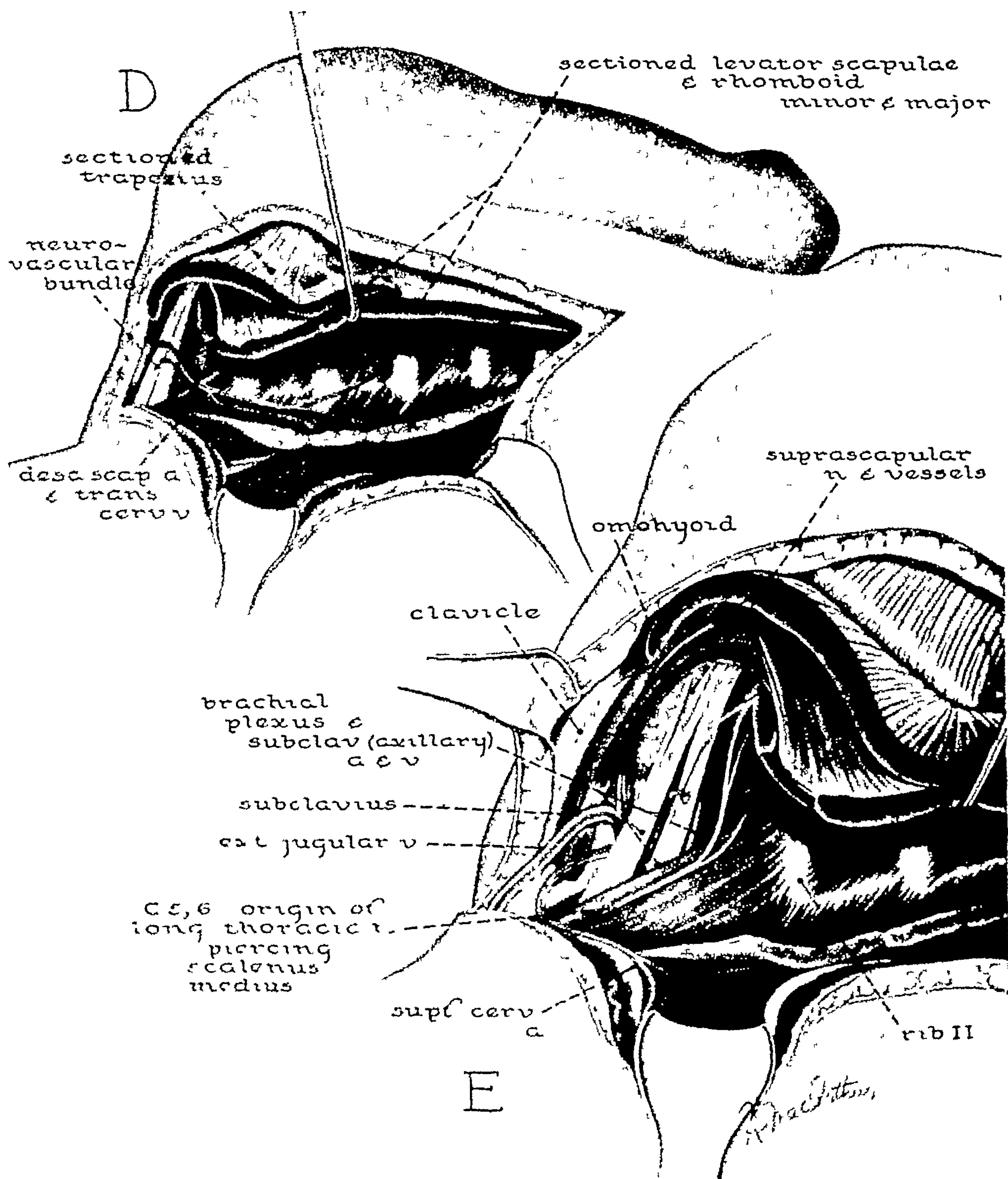

D
sectioned levator scapulae
& rhomboid
minor & major
sectioned
trapezius
neuro-
vascular
bundle
desc scap a
& trans
cerv v
suprascapular
n & vessels
omohyoid
clavicle
brachial
plexus &
subclav (axillary)
a & v
subclavius
ext jugular v
C 5, 6 origin of
long thoracic n.
piercing
scalenus
medius
supf cerv
a
rib II
E

PLATE XI

PLATE XI

THE FOREQUARTER AMPUTATION FROM THE POSTERIOR ASPECT (LITTLEWOOD'S TECHNIQUE)

With the completion of the division of the posterior muscles binding the scapula to the thorax, the surgeon should proceed to expose the neurovascular structures which are embedded at a considerable depth in fibro-fatty tissue At this point the descending scapular vessels, which bear a close relationship to the cords of the brachial plexus, may be encountered The artery usually passes between the cords while the vein may course around the anterior aspect of C_5, C_6

In Figure D the general relationships will be seen while in Figure E this important area is magnified and shown in considerable detail

If the viewer proceeds in Figure E postero-anteriorly he should note in sequence the branches of C_5, C_6 perforating the scalenus medius to join with a branch from C_7 to form the long thoracic nerve (Bell) which supplies the superior digitation and all other parts of the serratus anterior The cords of the brachial plexus then come into view They largely cover the subclavian artery as it comes forward between the scalenus anterior and medius in its third part to cross the first rib and becomes the axillary artery Although the second rib can be easily localised, the first rib can only be found by palpation and the artery is best recognised by its pulsation against this rib The subclavian vein lies more anteriorly, therefore more deeply, and in this position it is joined by the external jugular vein The close proximity of the pleural dome should be remembered as it is easily perforated during the dissection of the neurovascular structures

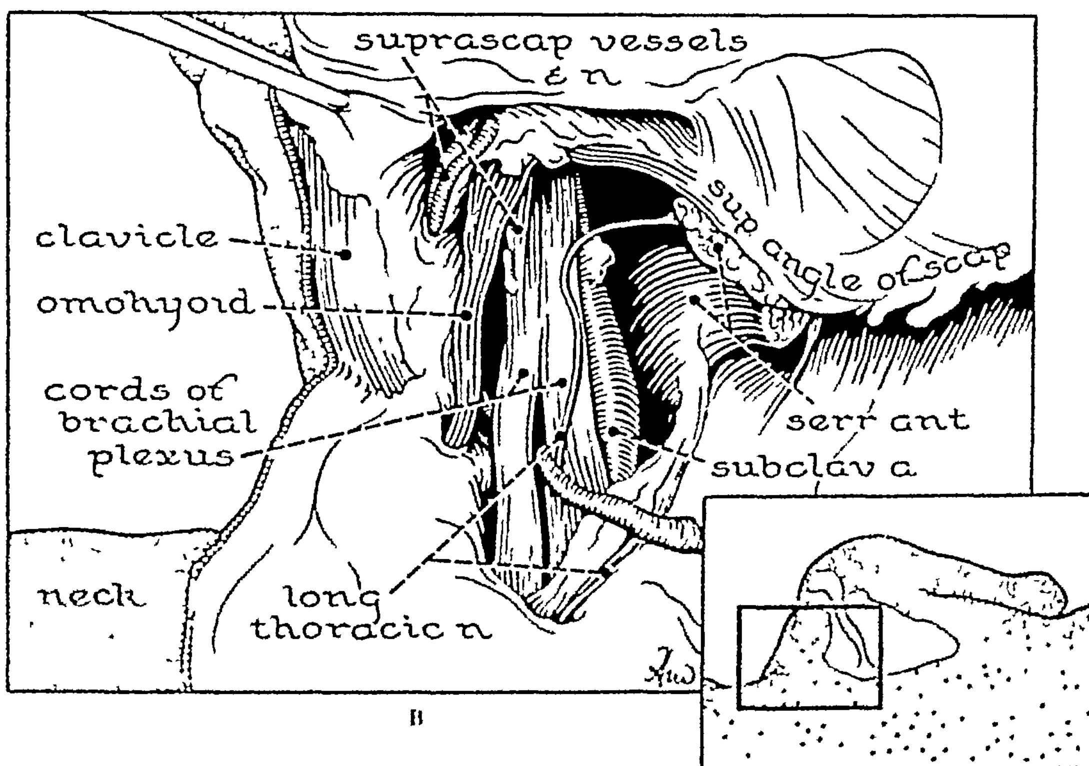
More anteriorly the posterior belly of the omohyoid accompanied by the suprascapular nerve and vessels can be seen in their relationship to the suprascapular notch The final localising landmark anteriorly is the clavicle with the related subclavius muscle The fasciæ which invest these structures have been omitted for the sake of clarity but can be reviewed in Plate VI

To complete this stage of the operation, each cord of the plexus is individually dissected [illegible] divided with or without preliminary injection [illegible] hydrochloride The artery, followed by [illegible] then secured, ligated, divided, and the [illegible] transfixed The omohyoid muscle and [illegible] scapular vessels and external jugular vein [illegible] after preliminary vessel ligation Som[illegible] transect the clavicle near its sternal end or [illegible] late the bone at the sternoclavicular joint [illegible] division of the neurovascular structures, while others prefer to delay this step until the important vessels are divided and carry out the clavicular division as part of the anterior dissection

With the completion of the division of the neurovascular structures, the surgeon passes to the opposite side of the patient and the anterior dissection is performed as can be understood from Plates V, VI, VII, and IX



A



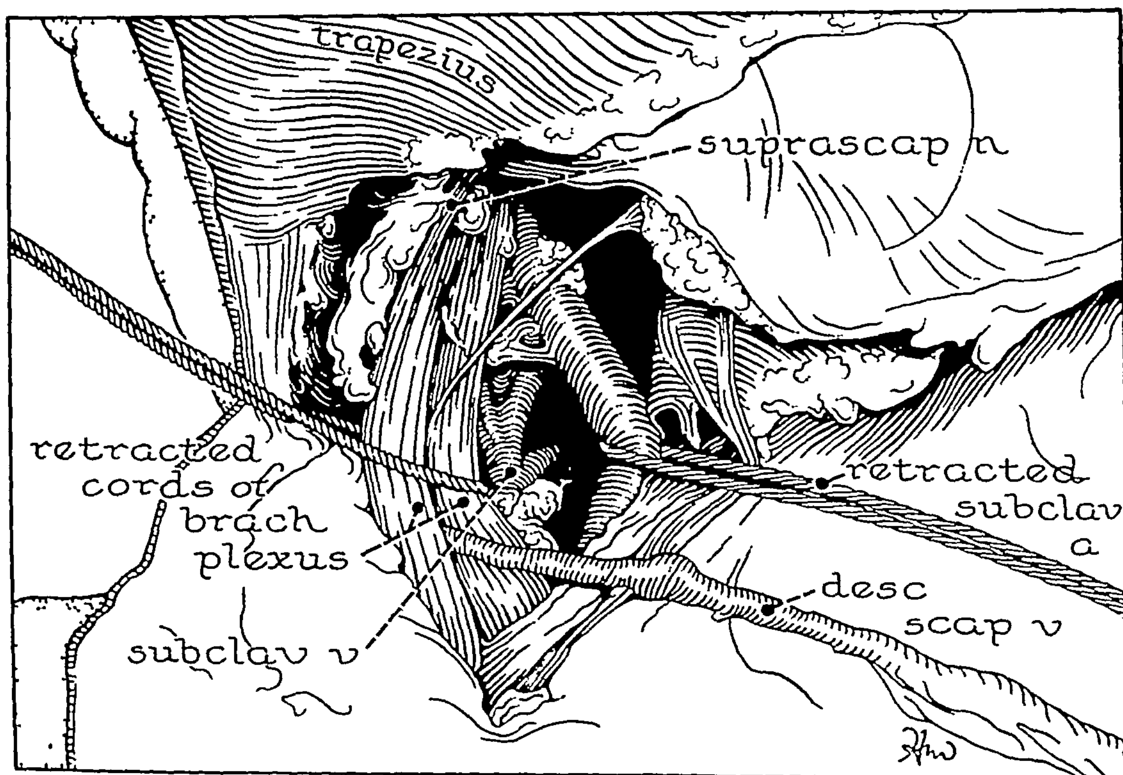
B

FIG. 12

The brachial plexus and subclavian vessels from the posterior aspect. See also Plates III, IX, X and XI.
A. Anatomical dissection.
B. Diagrammatic key. Note orientating inset.



A



B

FIG 13

The brachial plexus and subclavian vessels from the posterior aspect
A Identical with Figure 12, A, except for retraction of cords of brachial plexus and subclavian artery to expose subclavian vein
B Diagrammatic key to above dissection

THE ARTERIAL PATTERN IN RELATION TO THE FOREQUARTER AMPUTATION

The two line drawings in Figure 14 serve to illustrate in diagrammatic fashion the arterial pattern in relation to the forequarter amputation as performed from the anterior aspect [32] The information depicted can also be adapted to assist our understanding when the operation is performed from the posterior aspect or when partial ablation such as scapulectomy or the interscapulo thoracic resection is executed Study of the anastomoses will enable the surgeon to visualise the probable abnormal collaterals which will enlarge in rapidly developing sarcomata, involving the tissues of this region

The upper drawing shows the arterial anastomoses around the scapula which in light of the preceding illustrations can be tabulated as follows

1 The suprascapular artery
2 The descending scapular artery (deep branch of the transverse cervical artery)
3 The subscapular artery and its circumflex scapular branch
4 A branch of the posterior humeral circumflex artery
5 The acromial branch of the acromiothoracic artery

These arteries with their accompanying veins provide a rich vascular network in the soft tissues of the subscapular, supraspinous, and infraspinous fossæ

The principal drawing illustrates the arterial pattern in relation to the clavicle, scapula, and upper third of the humerus The points of the arterial section necessitated by the forequarter amputation as depicted on Plates V, VI, VII, and IX are indicated. The arterial channels which are removed when the forequarter is ablated are shown as cross-hatched, while those which remain are indicated as solid black As also found in the accompanying drawing certain collateral vessels are included The viewer should note the internal mammary and superior intercostal arteries which form anastomoses through the intercostals These may be enlarged in extensive neoplasms Further, these channels are accompanied by lymph channels (Plate IV) which should be studied in relation to neoplastic spread

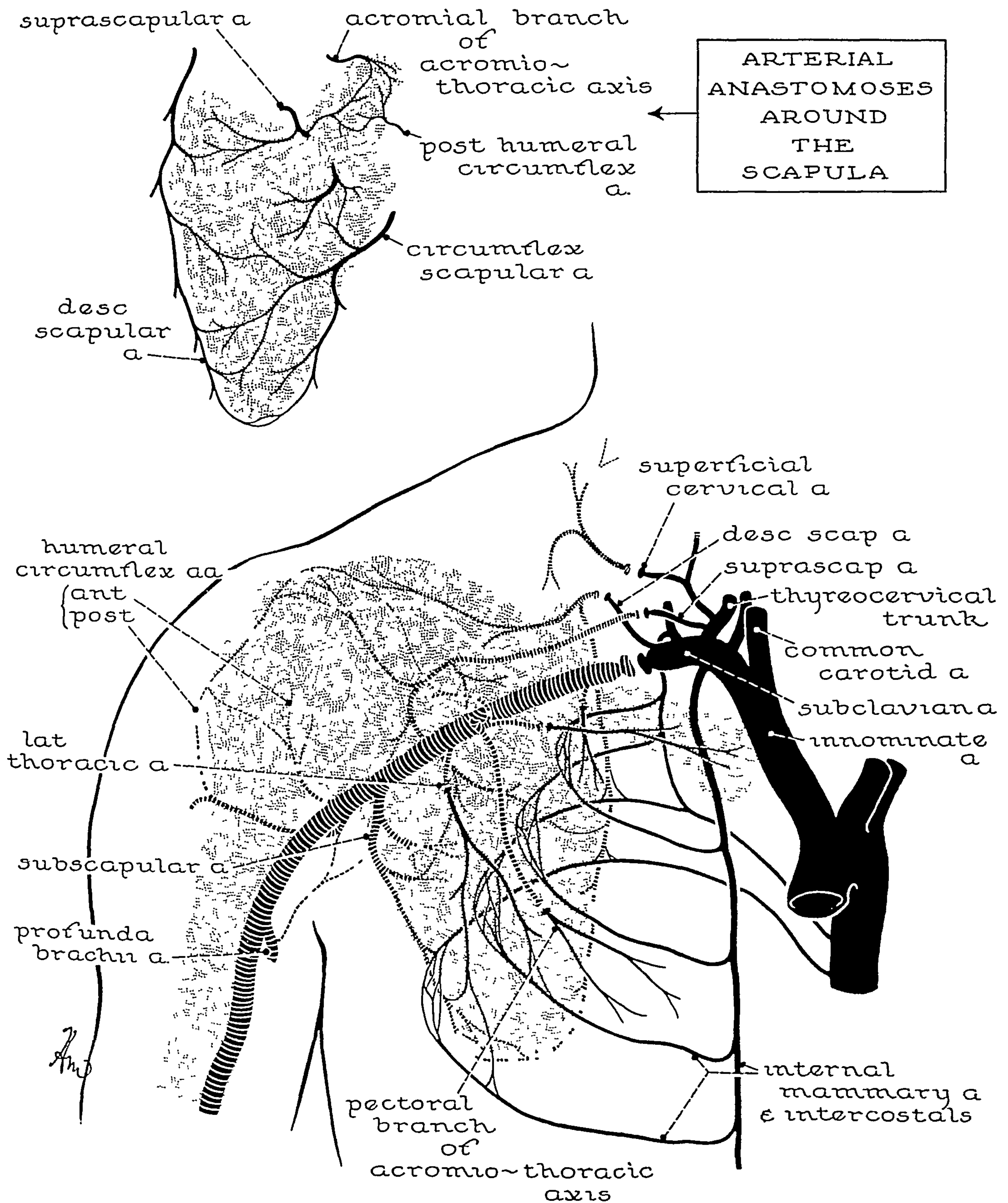


FIG 14
The arterial pattern in relation to the forequarter amputation

SCAPULECTOMY

The three drawings in Figure 15 serve to complement the information already given on Plates III, IX, X, and XI concerning the anatomical relationships which determine the technique of partial or total scapulectomy

When indicated, subperiosteal reflection of the supraspinatus, infraspinatus, and subscapularis muscles should be performed, and when this is possible an excellent functional result ensues as the scapular skeleton is often restored in part, especially in young individuals (Fig. 25) However, when these important muscles are lost for shoulder function, the eventual movement and power are considerably less, as seen from the case of Syme (Fig 5) and the illustrative case (Fig 24)

When possible, it is valuable to retain the acromion process with the attached deltoid and the coracoid with the short head of biceps and coracobrachialis These muscles with the long head of triceps should be anchored to the clavicle and chest wall to give whatever suspension of the upper limb is possible and practical

Steps in Scapulectomy

The posterior aspect of the scapula will be exposed through one of the incisions illustrated on Figure 16 The precise arrangement of the lines of incision will be determined in the case of large neoplasms by the position of the growth and the condition of the overlying skin

Flaps are made exposing the vertebral and axillary borders, the spine and superior angle Again, the exact approach for freeing the scapula will be determined by the lesion under treatment For the majority of cases the early steps can be followed in Plate X The trapezius with the deltoid may be subperiosteally reflected from the spine and acromion or division of the trapezius may be made as illustrated on that plate

The levator scapulæ rhomboids minor and major, and finally the serratus anterior are then sectioned Only a few branches of the descending scapular vessels will require ligation up to this point The inferior angle of the scapula is then cleared by detaching the latissimus dorsi, after which the scapula can be rotated to facilitate the remaining steps

If the axillary border is readily accessible, the long head of triceps and the teres major are then sectioned In this area branches of the dorsalis scapulæ vessels will require ligation Care should be taken to avoid injury to the circumflex nerve and vessels and to the posterior aspect of the neurovascular bundle depicted in Figure A

The scapula is freed from the clavicle by section through the acromioclavicular joint and coracoclavicular ligaments, or the clavicle can be sectioned medial to the coracoclavicular ligaments as meets the needs of the surgeon By rotation of the humerus the rotator cuff is severed leaving a stub, and the remaining attachments including the coracobrachialis and biceps, pectoralis minor, omohyoid and related suprascapular nerve and vessels are divided

The scapula with its related muscles and including the lesion under treatment can then be removed The structures ablated can be understood from Figures B and C which show the scapula from the posterior and anterior aspects with the related muscles, nerves, and vessels labelled for review (*see also* Fig 14)

In closing the wound, consideration must be given to the problems of providing suspension for the upper limb The coracobrachialis and biceps, as also the long head of triceps, are best fixed to the clavicle, The deltoid should be sutured to the cut edge of the trapezius

Some of the anatomical points underlying the interscapulo-thoracic resection (Fig 17) can be understood from this figure as it is seen that the upper end of the humerus could readily be removed with the scapula by substituting section of the humerus at the required site for section of the rotator cuff

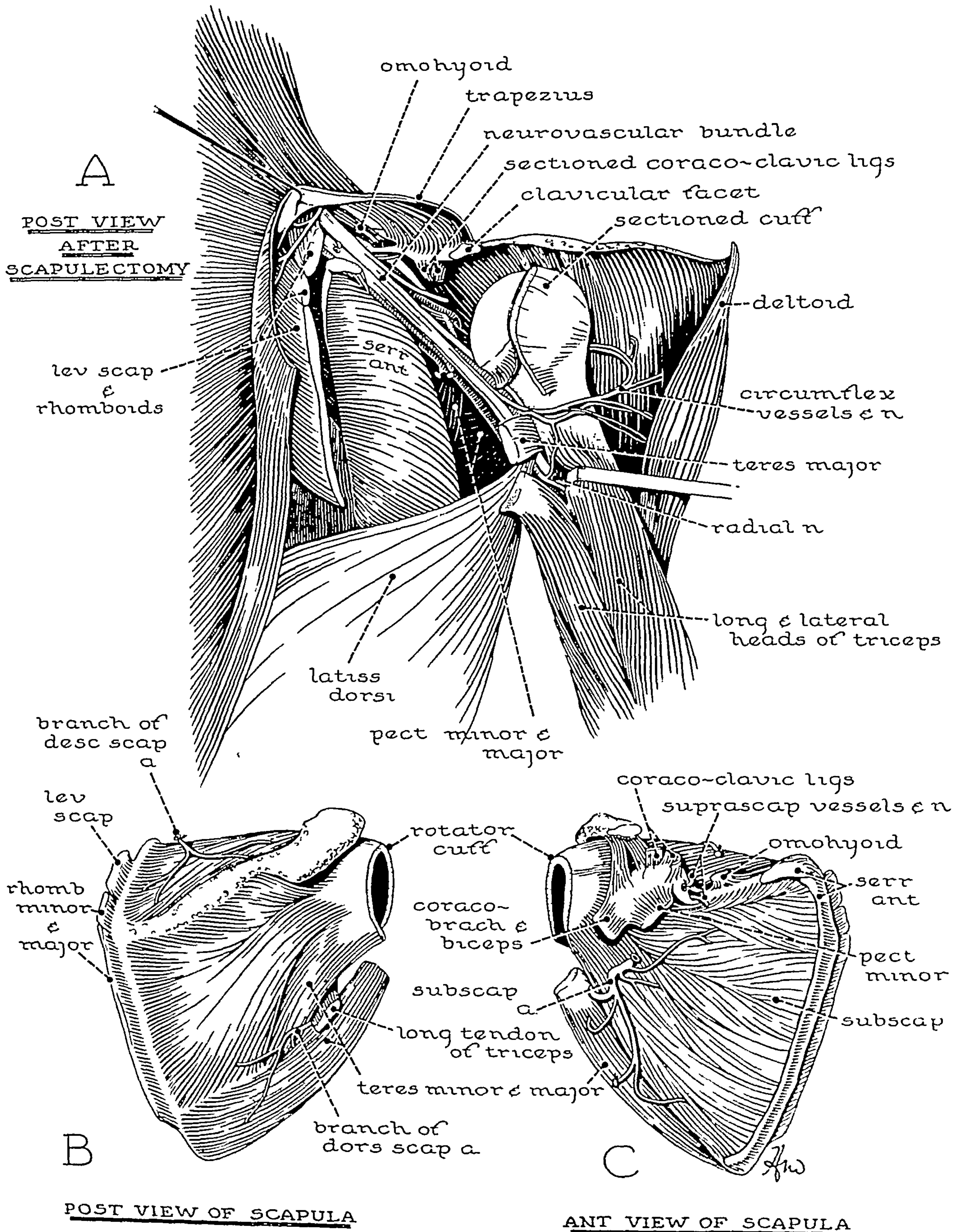


Fig 15
Total scapulectomy

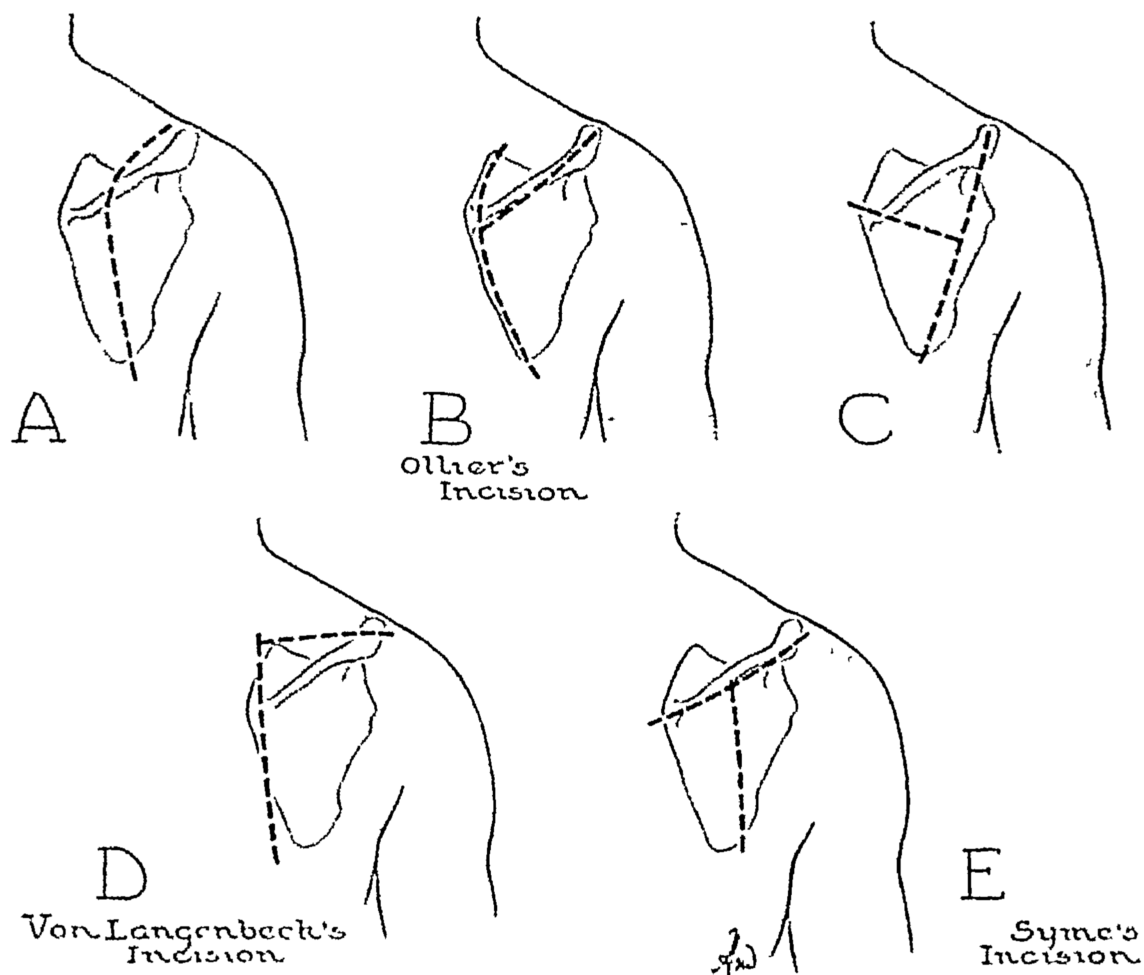


FIG. 16
Various skin incisions for total scapulectomy

INTERSCAPULO-THORACIC RESECTION

This procedure, which includes removal of the scapula, the upper end of the humerus, and a varying portion of the lateral end of the clavicle, has been described by Tikoff, Linberg, Bauman, and Pack As its uses are extremely rare, detailed coverage is unnecessary.

It may be indicated in cases where the neurovascular bundle is free of disease and the patient refuses a forequarter amputation

Figure 17 illustrates the case of Dr George T Pack where the procedure was used for a squamous cell carcinoma involving the scapula, which had received intensive radiotherapy with resultant sinuses, radionecrosis of the scapula, suppurative arthritis of the glenohumeral joint, and chronic fibrosing osteitis of the upper end of the humerus

The technique differs only in moderate degree from that described for scapulectomy The racquet-shaped incision extends along the clavicle and down the medial border of the biceps for three to four inches, thence superolaterally across the upper third of the arm

The pectoralis major and deltoid are detached from the clavicle and the neurovascular bundle exposed from the anterior aspect as in the early steps of the forequarter amputation performed by the Kocher technique The transverse cervical and suprascapular vessels are secured and divided

The posterior incision extends along the axillary border of the scapula, and from the inferior angle thereof the incision extends superiorly and laterally across the upper third of the arm to join the anterior incision

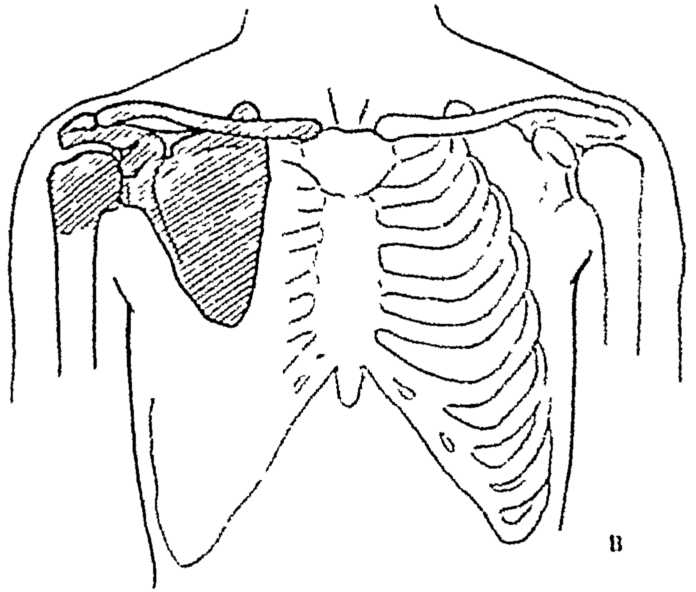
The remaining steps are as for scapulectomy except that the rotator cuff is not divided but the humerus is sectioned through the surgical neck The radial nerve and the circumflex nerve and vessels should be located and carefully preserved (Fig 15)

In closing the wound, suspension of the limb is more difficult but suture of the coracobrachialis and biceps to the stump of the pectoralis major and the long head of triceps to the remaining soft tissues of the chest wall should be attempted

Further details of this procedure can be obtained from the references appended [8, 69, 87, 107]



A



B



C



D

Fig. 17

The interscapulo thoracic resection

A. Deformity after resection of clavicle, scapula, head of humerus, and shoulder joint.
B. Schematic outline to show osseous structures sacrificed in the operation
C. Pre-operative roentgenogram illustrating destruction of scapula
D. Post operative roentgenogram

(Courtesy of Drs. George T. Pack and James C. Baldwin and Surgery, the C. V. Mosby Company)

V

Post-Operative Considerations

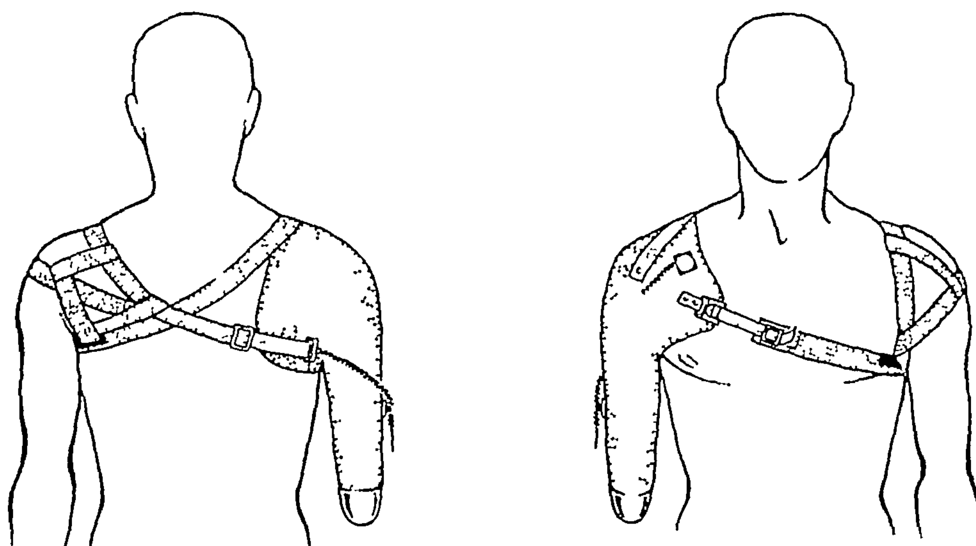


FIG 18
Plastic shoulder cap with short arm stump to give cosmetic symmetry in clothing
(*After* R D Aylesworth [6])

THE immediate post-operative care in the recovery room will include early recognition of excessive blood loss from the wound drainage and any fall of blood pressure The pressure dressing may require replacement

The primary dressing should be changed after twenty-four to forty-eight hours and the drain shortened or removed depending on the amount of drainage Early ambulation is desirable Antibiotic therapy should be continued until all possibility of infection has been removed

Wound healing is usually rapid and the patient may be ready for discharge after ten to fourteen days At this time the arrangements for a course of post-operative irradiation must be concluded

The question of the cosmetic appearance in clothes may be uppermost in the patient's mind In the early stages, the tailor or dressmaker can arrange a pad to afford symmetry to the upper trunk and shoulder area Later the decision as to the necessity for a light plastic shoulder cap with upper arm stump (Fig 18) or a dress prosthesis (Fig 19) can be settled In cases where the operation has been performed for palliation, a soft pad is often all that is required, but in others where long-term survival is expected a light-weight dress prosthesis is beneficial from a cosmetic and psychological point of view although its function is minimal The definitive care of such patients includes their rehabilitation (*see* Case LXVII[173])

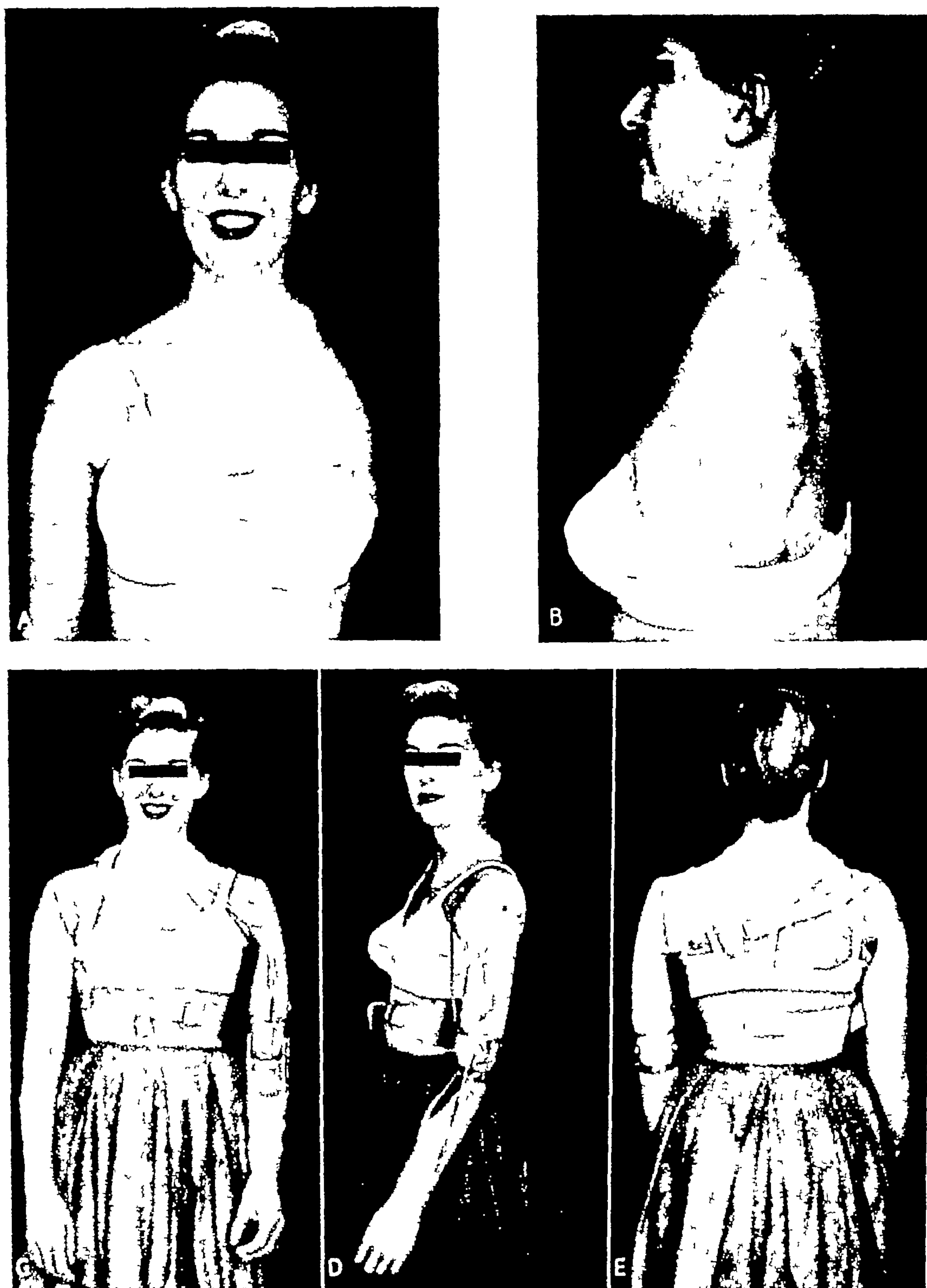


Fig 19

A Appearance after forequarter amputation anterior view
B Appearance after forequarter amputation lateral view showing scar of incision
C Dress prosthesis, anterior view
D Dress prosthesis lateral view
E Dress prosthesis posterior view
(By courtesy of Prosthetics Education Program University of California Medical Center Los Angeles)

VI
Illustrative Cases

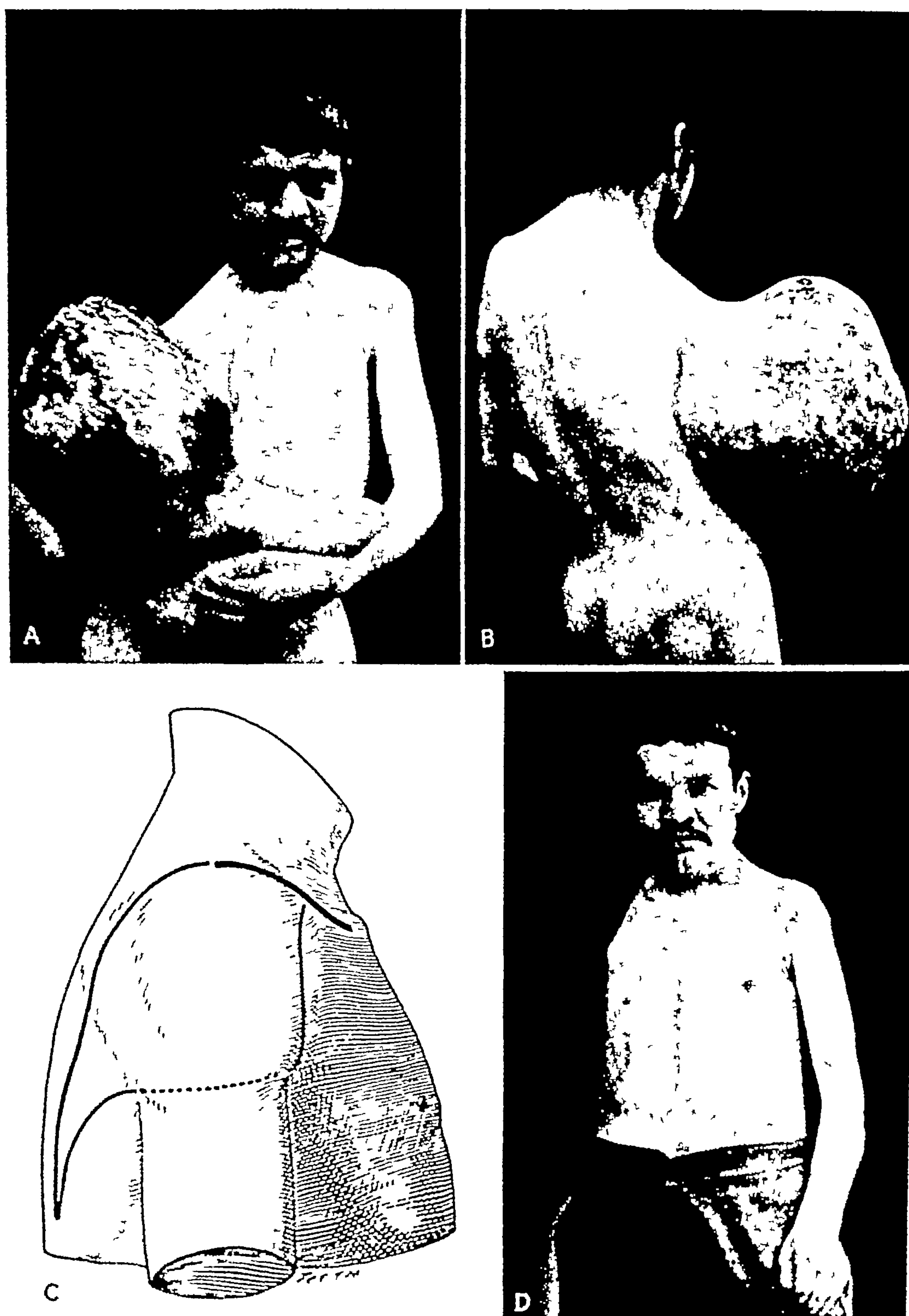


FIG 20



FIG 20

Berger's classic case of massive enchondroma of the superior extremity of the humerus Patient alive and well four years post-operatively

A Anterior view of patient, age 27 years Note that an amputation through the lower forearm had been performed at the age of 12 years for an enchondroma arising on the little finger

B Posterior view Circumference of tumour 95 cm

C Lines of incision used by Berger and attributed to Farabeuf

D Post-operative appearance, anterior view

E. Post-operative appearance, posterolateral view

F The prosthesis, anterolateral view

G The prosthesis, posterolateral view



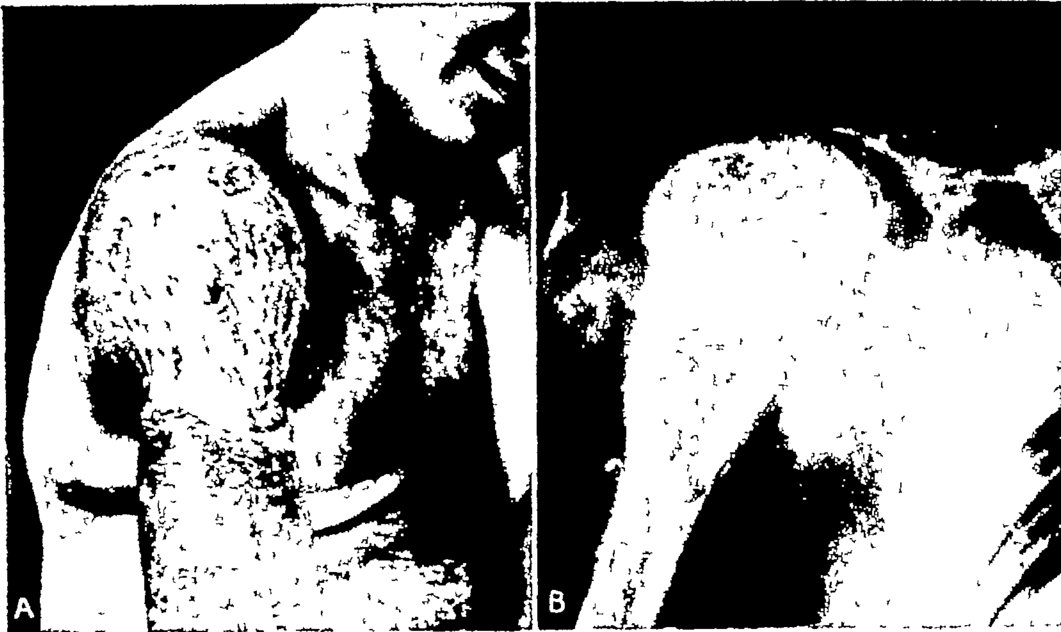




FIG 21

Case of Dr James J Callahan Male patient, aged 37 years; history of pain in the right shoulder region of six months duration Biopsy revealed an osteogenic sarcoma

A Clinical appearance before operation Intensive pre operative X-ray treatment given, resulting in thrombosis of the right subclavian artery and vein

B Radiological appearance

C Post operative photograph Post-operative X-ray treatment was given Patient alive ten years later Microscopic studies showed chondrosarcoma



FIG 22

Author s case male age 47 Patient had severe burn of the left upper limb and thorax at the age of 16 years Carcinomatous changes occurred which necessitated upper arm amputation in 1952 In December 1952 biopsy of an axillary mass showed squamous cell carcinoma Referred to the author January 1953

A Pre-operative appearance

B and C Appearance after secondary fore-quarter amputation performed January 1953 Death occurred eleven months later from cerebral metastases There was no evidence of local recurrence

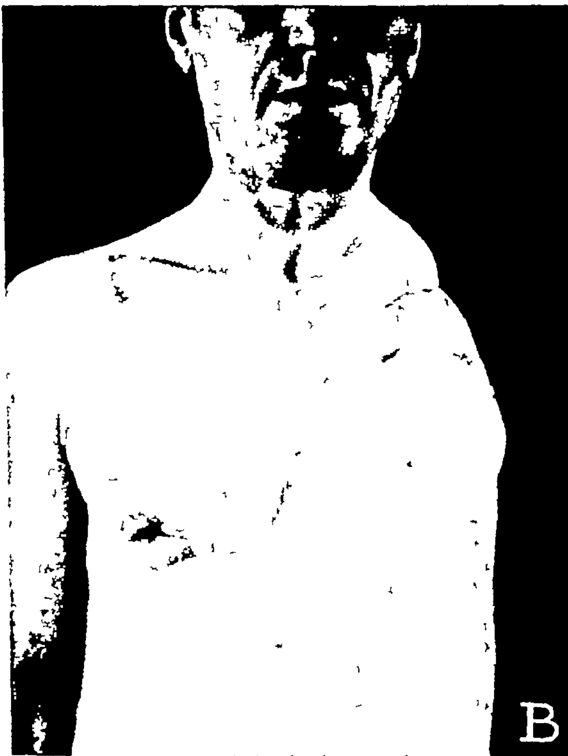






Fig 23

Fig 23

Author's case female age 73 Eight months previously, local resection of squamous cell carcinoma present on dorsum of hand for sixteen months Rapidly developed epitrochlear metastases which were biopsied. Multiple recurrences developed in this area and in the axilla Intensive radiation had been given to the axillary and epitrochlear regions Referred to author for forequarter amputation six months after biopsy of epitrochlear glands

A and B Appearance following forequarter amputation Died thirteen months postoperatively from local and pulmonary metastases

C Radiological appearance post-operatively

Fig 24

Case of Drs H L McLaughlin W W Werley and R R. Impink Male patient, age 42 had a mass arising from the axillary border of the right scapula which on biopsy showed fibrosarcoma Scapulectomy by Dr McLaughlin October 1950 Patient alive and well at the time of this publication A X-ray appearance with arm in its resting position Note that the acromion process has been fixed to the clavicle to give stability to the deltoid and that the coracoid process with its attached muscles remains in situ

B Shows the position of the humerus in maximum abduction

C Clinical photograph showing cosmetic appearance arm in resting position

D Photograph showing maximum active abduction, anterior view

E Posterior view, resting position

F Posterior view, maximum abduction

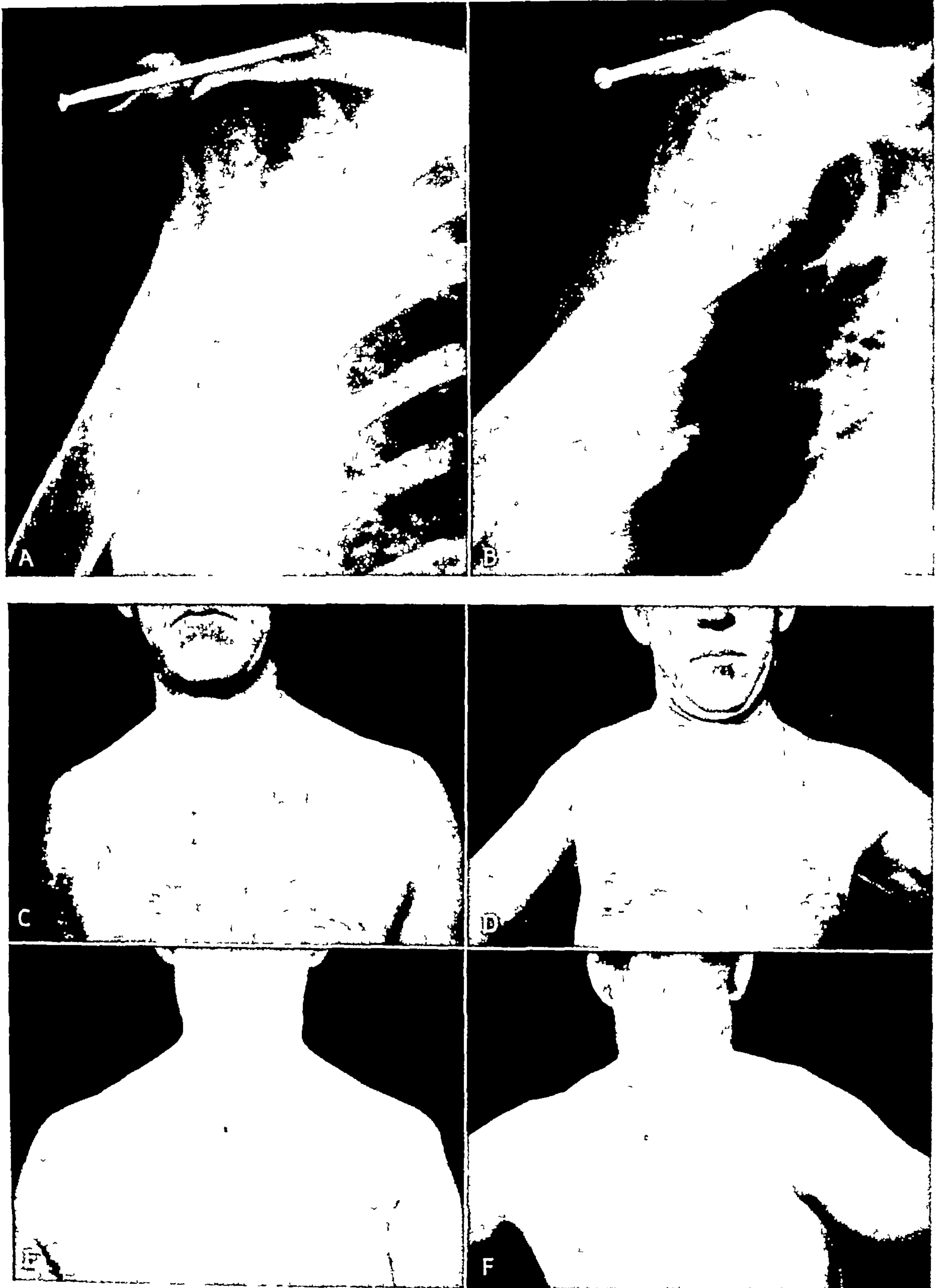


FIG 24



A B



C

FIG. 25

Case of Dr L. S. James. Female patient, age 10 years. Presented with an expanding cystic tumour of the right scapula which had previously been treated by curettage and packing with bone chips. The pain and swelling recurred. A subperiosteal resection of the scapula was therefore made, leaving the acromion process. Pathological diagnosis: aneurysmal bone cyst. This case has been published by Dr James in the *Journal of Bone and Joint Surgery*, 39B, 128-130, 1957.

A. Post-operative photograph showing cosmetic appearance, anterior view.
B. The healing wound showing point of drainage.
C. *Post-operative X-ray. This patient obtained a good functional result and the scapula is* reforming.

VII

Traumatic Forequarter Amputations

(in chronological order)

CASE I

1737 Belcher[110] *Male, age 26, left side*

The man, Samuel Wood, was carrying a rope which caught in the cogs of a large mill-wheel and his body was raised from the ground until checked by a beam, whereupon his arm and shoulderblade were torn off He was able to descend a narrow ladder and walk eighty yards before fainting from loss of blood Later in the day a surgeon could not find the large vessels, and as there was no further hæmorrhage he brought the fleshy parts of the wound together by needle and ligature and applied a dressing Next day he was admitted to St Thomas's Hospital where the dressing was not disturbed for four days, when Mr Ferne opened the wound and finding no blood-vessels " dressed him up again " Cure was complete in two months (*See Frontispiece*, Fig 2, and also pp 1-2)

CASE II

1808 Cuming, R[111] *Male, age 21, side not stated*

Dr Copland Hutchison saw this patient in 1808 The operation had been performed by Dr Ralph Cuming, Surgeon to the Naval Hospital at Antigua (*See* Fig 3)

CASE III

1819 Mussey, R D[112] *Male, age 16, left side*

This lad was caught by a machine in a cotton factory Two hours after the accident the surgeon found a large oval-shaped wound covered with a material resembling white of egg and with the collar bone projecting at the upper part, less than a pint of blood had been lost Hanging from the wound were two large nerves 20 in long, and when these were cut off the patient complained of pain which he referred to the hand on the injured side A little below the collar bone was a coagulation as large as the finger tip which beat as a pulse No ligature was applied to any vessel nor were stitches employed in the wound, compression bandage and adhesive strips constituted the dressing In two w the wound was almost healed, entirely so in eight w

A witness of the accident stated that the ma had been temporarily stopped by the resistance o patient's body, and experiments showed that this r ance amounted to a weight of 839 lb

CASE IV

1829 James, G W[113] *Male, age 10, side (?)*

The boy was caught by a chain attached to a st engine There was no great hæmorrhage and little p he walked twenty to thirty yards to his father fainted Two days of exhaustion were followe irritative fever and large suppuration Treatmen tonics and opium cured the patient in three months

CASE V

1832 Scarnell, S F[114] *Male, age 13, right side*

This boy was caught by a chain in the upper s of a mill, and being drawn against the roof his arm scapula with all its muscles were dragged off an body fell The finger-like projection of the clavicle removed, vessels secured and wound covered with integuments as remained, and a light dressing ap The general health suffered very little He was ab walk at the end of a fortnight, and on the third Su went to church

CASE VI

1833 Braithwaite, J[115] *Male, age 12, right side*

On 12th July 1832 the boy was caught by the of a carding machine Hæmorrhage was not prof the artery was secured by a single strong silk thread the vein also ligatured The flaps were adjusted secured by two ligatures and plaster straps and ban applied Healthy purulent discharge occurred on eighteenth day and granulations were encourage injecting a solution of alum one drachm to a pint was successful after seton had failed The patient perfectly well three months later

CASE VII

1836 Pirondi S[116] *Male age 14, left side*

In the report on his own case (1855) Pirondi recalls that while visiting the Edinburgh hospitals in 1836 he saw a child of 10 years whose right arm had been torn off by a machine together with the scapula clavicle, and the soft tissues of the shoulder, which were separated from the trunk as if by dissection Hæmorrhage was negligible, and at the twelfth day cicatrisation was well advanced

CASE VIII

1838 Gaetani-Bey[117] *Male age 14, left side*

On 31st December 1838 the boy was working at a foundry and was the victim of an explosion which lacerated his arm, shoulder, and scrotum The left spermatic cord was severed by the flying metal and the bony structures of the shoulder so smashed that amputation was necessary The lacerated integuments were fashioned to form a covering to the extensive wound and in fifty-five days after the operation the patient had completely recovered

CASE IX

1838 Larrey[118] *Male, age 14*

This boy had a gunshot comminution of the bones of the scapula and arm These were removed by operation

It was reported that this subject received so severe an injury of the scrotum at the same time that castration was necessary The patient recovered

CASE X

1842 Cartwright[119] *Male, age 14, left side*

In the museum at King's College there is a preparation (made before 1842) from which the annexed figure (131) was taken The patient, a lad of 14 years of age, was under the care of Mr Cartwright of the Middlesex Hospital and made a good recovery

CASE XI

1842 Lizars[119] *Male age 13*

This boy was the victim of a machine accident The axillary vessels and nerves hung loosely from the wound there was little bleeding and no shock The subclavian artery was ligatured the edges of the skin brought together as closely as possible and the patient made a rapid recovery

Fergusson said the case occurred many years ago during his connection with the Royal Infirmary in Edinburgh The boy came under the care of Mr Lizars

CASE XII

1842 Cooper.[120] *Male, age 7.*

This boy suffered a machine accident in which the arm and two-thirds of the scapula were torn off The clavicle and remains of scapula were removed by operation Patient made a rapid recovery

CASE XIII

1843 King, A[121] *Male, age 15, left side*

On 10th October 1843 the boy was caught in a mill-shed After the accident he fainted for a few seconds Total loss of blood was not more than two teacupfuls The nerves were torn and the slightest irritation gave rise to acute suffering The axillary artery was secured by a ligature and the integuments drawn together by adhesive plaster Reaction was trifling and on the tenth day the boy was lively and cheerful, though in terror when the exposed plexus of nerves was touched The ligature lay in contact with the nervous mass and was left to drop off with the sphacelated nerves about the sixth week, when the patient was in perfect health

CASE XIV

1845 Lewis, W[118]

Patient suffered multiple injuries in a machine accident Interscapulo-thoracic amputation was performed, but patient died from shock soon afterwards

CASE XV

1855 Pirondi, S[116] *Male, age 39, left side.*

On 29th June 1855 the man was crushed by the fall of a large stone and suffered multiple injuries The shoulder joint was mashed but the artery had escaped damage and was seen beating strongly in the axilla Having amputated the arm the artery was tied as high as possible and the comminuted scapula removed The wound was covered by a large posterior flap and the anterior part by soft tissue that had escaped injury Little blood was lost and the patient's condition was satisfactory after the operation but soon after he sank and died Post-mortem examination revealed a large laceration of the right lung and much blood in the chest

CASE XVI

1856 Parise, M [122] *Male, age 16½, right side*

On 26th August 1856 the youth's arm and shoulder were crushed in a machine accident. The brachial plexus was denuded as if by dissection The subclavian artery and vein were tied and the arm, scapula, and external part of the clavicle removed Recovery was uneventful except for suppuration, which lasted two months The patient had robust health until 1882, but became alcoholic and committed suicide in 1885

CASE XVII

Between 1856 and 1869 Parise, M [122]
Male, age 14, left side

The arm and shoulder were crushed in the gears of a machine The flaps of a large wound extended anteriorly above the clavicle and posteriorly to the lower part of the neck Comminuted fractures of the humerus and scapula were present Parise tied the subclavian artery, but the proximal end of the avulsed subclavian vein could not be found as it had retracted into the superior opening of the thorax The whole upper limb, the scapula, and half the clavicle were removed and the flaps closed The wound became infected and the patient died on the twelfth day Autopsy disclosed phlebitis of the left subclavian vein extending to the superior vena cava The stump of the subclavian vein was full of pus

CASE XVIII

1857 Horlbeck, H B [123] *Male, age 35-40, right side*

On 11th September or December 1857 this man, a muscular negro, was pounding resin when his arm was drawn into the machine and he was carried round till his body was stopped by a beam, when the arm and scapula were stripped from the trunk, which fell to the floor There was little hæmorrhage or pain except for a "burning" in the wound for which tincture of opium was given The patient suffered no shock, rested well, and lost not a drop of blood during treatment, which consisted of bringing the skin edges together after cleansing the wound and securing them in position by means of adhesive strips Healing was complete by the sixth week when the patient resumed his work

CASE XIX

1860 Niepce [124] *Male, age 32, left side*

On 17th December 1860 the man had his arm torn off by a wheel and the bones of the shoulder were so crushed that it was necessary to perform the inte scapulo-thoracic operation The patient made an u eventful recovery

CASE XX

1864 Jackson, V [125] *Male, age 35, right side*

In December 1864 this man was struck on the bac with the buffer of an engine, the wheel of which ra over and crushed his arm with the loss of a considerab amount of blood As the scapula was comminuted it removal, except for the acromion process, was per formed Four vessels were tied, each being ligatur immediately it was cut Flaps were approximated ar held with wire sutures and water dressing applied Patient died next morning

CASE XXI

1866 Lowe [126] *Male, age 18*

On 16th May 1866 the man was caught in a cardin machine and his entire upper limb torn to pieces w very little hæmorrhage When admitted to hospital h was in a state of collapse, the artery and vein wer denuded and lying in the wound Under chloroform the vessel was ligatured and the exposed part cut off as well as that of the nerve plexus The outer third of the clavicle was removed and the flap brought together and held by three loose stitches and a dressing applied

Five days later there was much delirium, followed by a copious discharge together with some large pieces of slough which came from the interior of the wound Delirium had now ceased and patient was ordered mutton chops, etc, *ad libitum* He steadily improved and was discharged cured in five weeks

CASE XXII

1866 Buchanan, G [127] *Female, age 17*

This patient was caught in a milling machine on 26th December 1866 Under chloroform the compound comminuted scapula was removed, the axillary artery having been previously secured There was very little hæmorrhage and the patient partly rallied but soon became exhausted and died of shock

CASE XXIII

1869 Jones, T E [128] *Male, age 11, right side*

In November 1869 the boy was entangled in a rope and was drawn between an iron rod and a wooden frame 6 in apart, his arm and scapula being thus separated

from the body He lost some blood, fainted and was in a state of shock for six hours The median and ulnar nerves were then cut away and the axillary artery secured Two inches of the clavicle were removed and the soft parts brought together by metallic sutures, wound was dressed every four hours with carbolic lotion Healing was complete in three weeks and in two months the boy was perfectly well and running about

CASE XXIV

1869 Paris, M[128] *Male, age 35, left side.*

In 1869 the man suffered a machine injury which necessitated the surgical removal of the left arm, more than half of the clavicle and the greater part of the scapula The subclavian artery and vein were ligatured while the posterior border of the scapula, being uninjured, was preserved with its attachments in the hope that suppuration in this region, which had occurred in a former case, would be prevented but the patient died on the eighth day of pneumonia

At the post-mortem examination it was found that several ribs were fractured two of which had pierced the lungs Also present was a fracture of the fifth cervical vertebra

CASE XXV

1869 Thayer S W[129] *Male age 12*

The accident occurred in the summer of 1869, and there was more hæmorrhage than usual in these cases The subclavian artery was ligatured and the outer end of the clavicle removed The patient had several fractures and was badly contused in various parts of the body but made a perfect recovery

CASE XXVI

1869 Watson, P H[130] *Male age 13, left side*

On 23rd March 1869 John R was working in a paper mill when his arm was caught between two pinion wheels, At the Royal Infirmary, Edinburgh he was placed under chloroform and was found to have suffered avulsion of the arm the shoulder almost denuded of skin, and the muscles and fasciæ exposed as if by dissection

In order to obtain a sound cicatrix it was necessary to amputate the scapula and clavicle During the separation twenty vessels were tied but not more than 2 oz of blood were lost The wound was washed out with 1 40 carbolic acid solution and the edges were brought together and sutured Progress was slow until the thirty-third day when carbolised dressings were abandoned Patient was discharged cured after seventy-four days' treatment

CASE XXVII

1870. Lunn[131] *Male, age 4 right side*

On 29th August 1870 Wm C was caught in the spokes of a cart wheel and his arm and scapula were torn from all attachments to the body except the skin of the axilla two nerves of the brachial plexus and the latissimus dorsi muscle There was no hæmorrhage; the torn end of the artery lay twisted in the wound The flaps healed in great part by first intention, and three weeks after the accident the child was running about the ward

CASE XXVIII

1870 Charles, J J.[132] *Male, age 10, right side*

In the morning of 14th September 1870 the boy was caught in the wooden roller of a mill Five hours later the surgeon found him cold and weak with the greater part of the upper third of the humerus and whole of the scapula almost torn away The limb was separated from the body, and flaps as large as possible made from the soft tissues of the shoulder The edges were adjusted and sutured and the wound covered with a water dressing there being no carbolic acid at home Two days later patient's condition had much improved, and in three weeks the wound was nearly healed and his strength and activity regained

CASE XXIX

1871 Katholitsky, F[133] *Male, age 37, right side*

On 21st May 1871 the man, J S, was caught by a heavy cask being hoisted and was carried against a beam which stripped off his arm and shoulder blade with little hæmorrhage No pulsating or bleeding vessels could be seen, but the least contact with the exposed nervous plexuses gave great pain, which was a prominent feature in this case The flaps were brought together and held by four steel pins and by the thirty-fifth day the patient was able to walk out

CASE XXX

1873 Jessop[134] *Male age 14, left side.*

On 28th April 1873 John Clark's arm was caught between cog-wheels and when released he was able to walk a few yards and then fainted The soft tissues connecting limb with the trunk were almost entirely destroyed but there was little hæmorrhage Operation was performed under ether during shock Tissues of the

shoulder were dissected to make flaps and joint opened To form the posterior flap it was necessary to remove the scapula, during which air entered the subclavian vein The patient became deadly pale and pulseless, and restorative measures were applied while the operation was being completed For the first few days after operation the boy was feverish and delirious, and there was sloughing of flap which necessitated skin grafting, but by the nineteenth day the wound had healed perfectly

CASE XXXI

1874 Hendry, G[133] *Male, age not given, left side*

Samuel Watson's left arm was caught between the belt and pulley in a shingle mill He was carried around the shaft four times before the arm was torn off and he was thrown to the floor

The scapula and outer 1¾ in of clavicle were removed The vessels, which had bled very little, were ligatured The wound was cleansed and the skin sutured

Infection supervened and some of the skin sloughed, skin grafting was required, but the wound finally healed

CASE XXXII

1876 Gundrum, F[136] *Male*

On 2nd December 1876 boy John suffered a gunshot wound and several days had elapsed before a surgeon was called in He found the arm black and "mummified," and the sloughing process had extended over a great part of the shoulder After giving the patient 2 oz of French brandy, ether was administered and operation undertaken to remove the entire scapula with the carious end of the clavicle and remaining portion of dead humerus During the operation four vessels were ligatured and ten smaller ones twisted The enormous wound was washed out with carbolised water, closed with silk stitches, and dressed with lint and cotton wool Healing proceeded rapidly, patient was up in a week and made an excellent recovery

CASE XXXIII

1876 Weinlechner[137] *Male, age 16, left side*

On 20th July 1876 this lad fell asleep at his rolling machine and his arm was caught and separated from his body There was much damage to skin and muscle and comminution of the scapula necessitating its removal together with the remainder of the shoulder girdle In spite of antiseptic treatment and skin grafting progress was very slow and eighteen months elapsed before the patient was fully recovered

CASE XXXIV

1878 George, W H[138] *Male, age 29, right side*

A Mexican miner had his right arm and scapula t off by descending mine shaft on 4th September 18 Little hæmorrhage occurred No vessels required l tion and the skin flaps were drawn together with sut and adhesive straps

The wound was practically healed on the thirty- day except for a small cavity under the projecting p of the clavicle which remained in situ

CASE XXXV

1880 Wheelhouse[139] *Male*

This patient was treated at Leeds Infirmary for in for which interscapulo-thoracic amputation was quired No further details published

CASE XXXVI

1880 Ellis-Jones, J[140] *Male, age 17, right side*

On 10th September 1880, Wm L, a miner, suff a machine accident He was conveyed three mile his home where the surgeon sawed off the outer t thirds of the clavicle and ligatured the main art little blood had been lost The flaps were fairly bro together and dressings applied wetted with carb acid (1 40)

Wound healed except for a little gaping at the mi where there was scarcity of skin Infrequent dress were continued and in a month the patient was to take open-air exercise

CASE XXXVII

1881 Lewis, R F[141] *Male, age 26, right side*

His shirt sleeve was caught in the cogs of a mac and his right arm was completely avulsed carr with it the entire scapula denuded of all muscular tis Little bleeding occurred, about 8 in of the me nerve hung from the wound The patient made uninterrupted recovery The article contains an illus tion of the appearance

CASE XXXVIII

1883 Will, J C D.[142] *Female, age 18, right sid*

On 5th January 1883, Lizzie W, mill worker, injured by a flax-spinning machine There was hæmorrhage and the axillary artery was seen lying the surface of the wound, pulsating feebly, having b closed by torsion Patient was seriously collapsed the acromial end of the clavicle was removed wit anæsthetic Wound was washed out with 1 30 carb lotion and the flaps brought together and sutured Fi

9

the third to fifth day discharge was purulent, but then the patient regained strength and was discharged from hospital nineteen days after the accident

No part of the arm or scapula could be examined as they were reduced to pulp before the machine could be stopped

CASE XXXIX

1884. Lucas-Championnière, J.[142] *Male age 38 left side.*

On 30th June 1884 this man was caught in a machine and his arm torn off: there was little hæmorrhage Iodoform and a carbolised dressing were applied to the wound until patient recovered from shock, which lasted three days At operation the clavicle was stripped and divided, the subclavian muscle severed, and the artery and vein ligatured, nerves were cut off as high as possible The pectoral muscles being divided the shoulder was reversed to detach it from the thorax Much bleeding from small arteries was controlled with forceps, wound was washed out several times with strong carbolic lotion Patient collapsed on the operating table where he had to remain for two hours with head low Suppuration occurred during the next week but from the tenth day there was a notable improvement which was maintained and in a month the patient was walking in the ward

CASE XL

1884 Fornari, F.[143] *Male, age 21 left side*

This man suffered a gunshot wound of the upper arm which became gangrenous At the first operation the arm acromion and coracoid process were removed, but necrosis of the scapula necessitated its complete resection also

CASE XLI

1885 Loumeau[140] *Male, age 26, left side*

On 13th July 1885 the man's arm was caught in a cable and detached from the body together with the scapula There was no hæmorrhage the nerves showed as long white strings on the surface of the wound, which measured 18 cm long by 10 cm wide, the edges appeared clean cut as if by a scalpel Under chloroform the outer part of the clavicle was removed the nerves divided and as a precaution the axillary vessels ligatured, dressings rigidly Listerian

In addition to this injury the patient's left ear was almost torn off and the lower jaw fractured, but on the eighth day he got up and in six weeks was perfectly recovered

CASE XLII

1885 Schmidt, E.[144] *Male, age 7, left side.*

This young patient sustained in a railroad injury a compound comminuted fracture of the radius and ulna; extensive lacerations in the left shoulder with the humeral head torn from the glenoid cavity, the arm hung only by the brachial plexus and some strips of skin, compound comminuted fracture of the middle of the left clavicle and of the left scapula The ribs were widely exposed anteriorly, laterally, and posteriorly The hand was mangled The whole forequarter, including two-thirds of the clavicle, was removed under general anæsthesia

There were associated injuries to the right hand with loss of three fingers Extreme shock was present during the operation but the patient eventually made a perfect recovery

CASE XLIII

1886 Mazzoni, Gaëtano[145]

On 24th July 1886 comminuted fracture of the left arm and scapula Interscapulo-thoracic amputation (without the clavicle and part of the scapula) death at the end of thirty hours Transfusion Stimulation Ligature of the subclavian artery Death from œdema of lungs and acute anæmia

CASE XLIV

1887 Jeannel[146] *Male, age 26, left side*

On 24th April 1887 a lion savaged this man's arm and shoulder The subclavian artery and vein were ligatured and the following day amputation was performed

Less than 200 grams of blood were lost but the patient died three and a half hours after operation

CASE XLV

1887 Kirmisson E.[147] *Male, age 27, left side.*

On 23rd August 1887 this man suffered a gunshot wound of the axilla There was much hæmorrhage and he was admitted to hospital four hours later with profound shock Next day the bony structures of the shoulder were found to be crushed, no pulse in the arm Ligatures were placed on the axillary and subclavian arteries and the amputation performed No more than 100 grams of blood were lost, but at the end of the operation the patient became cyanosed and died in half an hour.

CASE XLVI

1887 Bourgougnon[150] *Male, age 30, right side*

On 25th January 1887 patient suffered a machine injury There was little hæmorrhage but shock lasted six hours The comminuted scapula was removed, the wound sutured, drainage tube inserted, and antiseptic dressing applied Two days later there was moderate fever but little discharge from the wound The patient walked on the fifteenth day and had fully recovered in a month

CASE XLVII

1889 Eiselsberg, F von[151] *Male, age 63, right side*

On 1st December 1889 the man, while in a drunken state, fell under a tramcar which ran over his upper arm and shoulder Brought quickly to hospital, the patient was found to be completely unconscious and suffering from a crush injury of the shoulder in which all the bones were involved and with extensive injury of skin and muscles, pulse not perceptible

Without anæsthesia the subclavian artery and vein were ligated, the arm amputated, and the splintered scapula resected as well as the outer two-thirds of the clavicle Skin flaps were insufficient to close the wound, which was loosely packed with iodoform gauze Attempts were then made to restore the pulse, but ten hours elapsed before it reappeared

The patient recovered slowly with periods of restlessness, there was a partial gangrene of the skin flaps, which were replaced by Thiersch grafts and the wound healed completely though slowly

CASE XLVIII

1895 Chavasse, T F[152] *Male, age 32, left side*

On 7th May 1895 the patient, M W, was entangled in the driving band of machinery by which the forearm was cut off and the skin of the arm torn in strips as high as the shoulder joint, muscles in this region were contused and infiltrated with blood The brachial artery and axillary vessels were exposed and cords of brachial plexus crushed To obtain adequate covering for the wound, amputation was performed within an hour of the injury The skin sutures of silkworm gut were removed a week later and in a month the patient was walking out of doors

CASE XLIX

1895 Fowler, G R[153] *Male, age 55, left side*

On 27th November 1895 the patient, P R, suffered burns of the entire surface of his arm and forearm Topical dressings were employed for eleven days when the whole arm was sloughing and foul smelling At operation the subclavian artery was exposed and tied The attachments of the scapular muscles to the trunk were divided and the scapula and outer fragment of the clavicle removed with the arm Three days after operation the patient became delirious with high temperature and died

CASE L

1899 Marshall, E[154] *Male, age 12, right side*

On 16th June 1899 the boy, A V H, was caught in the belt of a machine At operation all bony fragments were removed and part of the clavicle sawn off The subclavian artery was ligatured and the parts cleansed with bichloride solution 1 5000 There was little inflammation, and on the tenth day the patient walked across the floor On the twentieth day after the accident he walked nearly half a mile

CASE LI

1903 Pozzan, T[155] *Male, age 20, left side*

On 25th June 1903 the man, P G, put his hand between the teeth of a carding machine revolving at great speed In an instant his arm was caught and dragged out by the roots with but little hæmorrhage

The patient's condition was such as to negate operation, but by the third day gangrene and septicæmia obliged the surgeon to intervene as a last chance to save the man's life The operation field having been prepared by antiseptics, a portion of the clavicle was sawn off and this made it possible to trace and ligature the subclavian artery which was buried in œdematous tissue The scapulo-thoracic amputation performed on textbook lines, occupied forty minutes and little blood was lost Finally, the wound was washed out with chloride of sodium solution a drain inserted, and the flap and skin sutured The patient was able to walk in ten days and was discharged after thirty-five days with the wound almost healed

CASE LII

1904 Northrop, H L[156] *Male, age 19 months, right side*

This young child was injured in an elevator accident and the whole shoulder girdle was severed through the middle of the clavicle and along the line of insertion of the serratus anterior to the thoracic wall The only connection with the trunk was one cord of the brachial

plexus This was severed and the subclavian vessels ligatured

The patient, however, died presumably of pulmonary embolism Photographic records of the case are presented

CASE LIII

1905 Sablé M J [137] Male age 50 right side

This chauffeur had his arm caught in machinery and the forearm was avulsed from the humerus The humerus which was intact was, however divested of muscles over its lower third as if detached by a rugine The muscles of the upper third were crushed and torn There was considerable shock Under general anæsthetic a forequarter amputation was performed from which the patient eventually recovered

CASE LIV

1907 André [138] Male, age 17 left side

This patient's left hand was caught in a transmission belt which dragged him around a tree three times before throwing him to the ground His left upper limb completely avulsed, remained wound around the tree He uttered a single cry, did not lose consciousness, nor did any hæmorrhage occur The whole accident occurred in three or four seconds The clavicle remained in situ At the time of the operation the patient did not complain of pain and the pulse was 72 The outer two-thirds of the clavicle was removed and the subclavian vessels were ligated The wound was sutured with drainage Healing was complete in fifteen days and the patient made an uninterrupted recovery

CASE LV

1912 Ratnam C S [139] Male age 14, left side

Accident occurred in a coconut fibre mill in Ceylon Patient brought to hospital conscious but in shock one hour following the accident The whole upper limb was mangled necessitating immediate operation Under general anæsthesia the forequarter was removed There was difficulty in closing the skin but the patient made an uninterrupted recovery and was discharged from hospital seventy-nine days after the accident

CASE LVI

1914, Dickinson G K [140] Male age 23 right side

On 14th January 1914 the man, S Z, while oiling machinery had his right arm caught in a coal conveyor The muscles were wrenched off close to the body and the skin evenly torn After the injury he ascended a fifteen-foot ladder and walked three hundred yards to the office On examination it was found that the blood-vessels and nerves had been torn off and had receded There had been no hæmorrhage or pain The wound was swabbed out with tincture of iodine and a drainage tube inserted Recovery was uneventful

CASE LVII

1915 Pillet de Rouen [141] Male, right side

B Francois was wounded in the right shoulder on 26th September 1915 First-aid was given and two days later he was evacuated with a high temperature and œdema of the shoulder region The wound was explored and gross suppuration was found around the comminuted scapula which was removed His condition continued to deteriorate and the limb was amputated at the trunk In spite of multiple pyemic abscesses and erysipelas the patient eventually made a satisfactory recovery

CASE LVIII

1917 Wall, G A [142] Male left side

Left arm caught in revolving machinery with complete avulsion of the upper limb including the scapula The clavicle remained in situ The patient was brought to hospital in severe shock from which he recovered On the following day, under general anæsthesia, the wound was loosely sutured after removal of redundant tissues Later skin grafting was required but the patient made a good recovery

CASE LIX

1920 Moszeik [143] Male, age 14, right side

This boy, Paul J, was caught in a machine which wrenched off his arm and shoulder blade He lay senseless for twenty minutes before being found and brought to hospital, by which time he had recovered consciousness with no hæmorrhage or sign of shock After removal of dirt and blood the stump of the axillary artery was seen in the depth of the wound This was ligated and the outer half of the clavicle removed in order to bring the skin flaps together The wound healed and during his stay in hospital (period not stated) the boy learned to use the left hand as easily as he had used the right

CASE LX

1938 Lee, W D and Radcliffe F [144] Male, age 32, right side

On 26th March 1938 the man, D N, was caught between a belt and roller and his arm twisted out of

his body The patient was very shocked, but in four and a half hours he had recovered sufficiently for operation There was practically no bleeding The skin edges were excised and the brachial plexus crushed and tied as high as possible, the artery was also ligated in two places The outer half of the clavicle was sawn off, the skin edges approximated with sutures, and a drainage tube inserted A part of the wound discharged pus for a considerable time, but the patient's general condition was satisfactory during his three months in hospital

CASE LXI

1938 Killinger, R R[165] *Male, age 23, right side*

This foreman's fingers were caught between the rollers and belt of a large conveyor of gypsum rock The arm with the scapula was avulsed when the body was arrested by the grating The patient was brought to St Luke's Hospital in Jacksonville, Florida, where the wound was débrided and closed Antishock therapy, antitetanic, and anti-gas-gangrene sera were given The patient made an excellent recovery A photograph and X-ray show the post-operative appearances

CASE LXII

1940 Henson, E B[166] *Male, right side*

Right hand caught in a revolving wheel in a coal factory Lost consciousness when the limb was drawn in to elbow level, but was able to pull himself loose after a few moments

He walked up twenty steps and turned off the electric switch, and then went two hundred feet to find the foreman before sitting down He was brought immediately to the hospital Blood pressure before anaesthetic 90/60, pulse 120, respiration 28 Collapse of right lung due to open wound and fracture of fifth and sixth ribs

Wound cleansed under local anæsthetic and necrotic tissue removed A drain was placed in the open chest Vessels were ligated Right clavicle was intact Patient made an uninterrupted recovery

CASE LXIII

1947 Chen Min[167] *Male, age 55, left side*

On 25th April 1947 this man was run over by a train and his shoulder severely injured The scapula and head of the humerus were both badly fractured and a small piece of skin was all that united the avulsed forequarter with the trunk There had been considerable bleeding, and when seen four hours after the accident he was semi-conscious and in a state of shock At operation the forequarter was removed, torn muscles trimmed, vessels and nerves ligated, and the wound closed except for drainage tube Blood transfusion was given and penicillin and sulphadiazine therapy instituted Subsequent progress was smooth and patient was discharged forty days after the accident

CASE LXIV

1947 (?) Phillips, C L[168] *Hawaiian male, age 38, left side*

Left upper limb caught in conveyor belt in rock quarry and whole upper limb and scapula avulsed Clavicle remained in situ Little bleeding or shock, treated immediately in hospital and transfusion given Vessels ligated and nerves severed Wound packed with vaseline gauze Forty-eight hours later packing removed and wound closed with two drains

Patient made an uninterrupted recovery and photos are available showing the healed wound with an X-ray of the region showing the intact clavicle

CASE LXV

1948 Millar, J D C[169] *Male, age 23, right side*

This man, a miner, was caught between a roller and belt and twisted round so that his arm was avulsed from the body, no serious hæmorrhage On admission he was shocked but not in a serious condition At operation two and a half hours later it was found that the scapula and lateral half of the clavicle were missing and only portions of the shoulder muscles were present except the latissimus dorsi, which was intact The axillary artery and vein were ligated and the brachial plexus cut short and injected with 2 per cent procaine Antitetanic and anti-gas-gangrene sera were given and a course of penicillin started He was in hospital fourteen days and complained only of pain in his " phantom " limb

CASE LXVI

1951 Way, W V[170] *Male, age 38, right side*

On 15th November 1951 the man L D was caught in a cement machine and his arm was ripped out at the axilla together with the scapula and attached muscles A doctor, quickly on the spot packed the actively bleeding axillary and subclavian area, which was completely bare

On admission to hospital the patient was in a state of deep shock for which plasma and whole blood were given as soon as possible The exposed nerve ends of the brachial plexus were cut short and the axillary vein and artery tied, the wound was then thoroughly

cleansed by irrigation and the flaps brought together Condition was critical after the operation, but in four days temperature had dropped to normal

The only complaint was of " phantom " pain which subsided, but Horner's syndrome remained constant The patient was discharged twenty-three days after operation and resumed work a month later

CASE LXVII

1952 Otey, B T, and Skinner, E F[171]
Female, age 47, right side

This woman was accidentally drawn into a roller in a Memphis factory Right arm with girdle and breast avulsed Fractured ribs (1 - 10) with open chest on right side Compound comminuted fracture of left humerus with avulsion of brachial plexus, artery, and vein Case record gives complete details of management, including rehabilitation of this remarkable case Photographs demonstrate the result and function of the prosthetic replacement on the left side

CASE LXVIII

1956 Queinnec, André and Jocelyne[172]
Male, age 17, left side

This youth, G G, was engaged in sawing tree trunks in the Argonne forest when his foot slipped and he fell under a saw which sliced off his shoulder Hæmorrhage was profuse and his comrades, though expecting him to die on the spot, nevertheless transported him with all speed to the hospital of Ste Menehould, where he arrived in fifteen minutes and came under the care of M and Madame Queinnec, who specialised in resuscitation procedures

On examination he showed no signs of life except a feeble respiration, but with immediate treatment by oxygen and blood transfusion his condition improved, and at the end of three hours repair of the multiple lesions was performed in the following order suture of the stomach, of the diaphragm, of the pericardium, and of the lung, part of which was lying free in the pleural cavity

The lacerated parts of the muscles were then removed, and this was followed by ligature of the axillary vessels and nerve trunks after injection of procaine Finally muscles and skin were approximated without traction and sutured Penicillin and streptomycin were freely employed during these procedures

At the end of the operations, lasting three hours, the patient's condition was satisfactory but deteriorated several times during the next three weeks owing to fluid collecting in the chest At the end of this period a copious flow occurred at the site of the drainage tube, which was followed by a definite fall of temperature and closure of the opening

The patient left the hospital three and a half months after the accident for convalescence and re-education

VIII

Conclusions

1 Primary forequarter amputation offers the only hope of cure in certain cases of primary skin cancer and melanoma of the upper extremity, in certain cases of sarcomata of the soft tissues of the shoulder region, and in sarcomata arising in the bones of the shoulder girdle In Dr Pack's series of eighty-eight cases, 37 per cent of those having a secondary forequarter amputation for residual or recurrent carcinoma are living and well at the time of his end result study Further, he records that the five-year cure rates after this radical treatment for malignant skin tumours primary in the upper limb is 22 2 per cent , for soft part sarcomata of the shoulder region 39 3 per cent , but for sarcomata arising in the upper end of the humerus or scapula there is no record of survivals of that duration

2 The primary operation is preferable to the secondary forequarter amputation and should be performed at the earliest possible moment

3 There is a place for scapulectomy in a limited field, especially for large chondromata, secondary chondrosarcomata, in cases of aneurysmal bone cysts, and hæmongiomata primarily involving the scapula Records of scapulectomy in cases of radionecrosis following radiation therapy for overlying skin carcinoma show good survival rates and satisfactory function

4 There is a small place for interscapulo-thoracic resection in selected cases of malignant disease when the neurovascular bundle is not involved and the patient refuses loss of limb

5 Traumatic avulsion of the forequarter has been recorded from time to time in the surgical literature and can occur with little hæmorrhage or shock It is probable that the cases recorded have tended to be those in which recovery has occurred, and that those that died have passed unnoticed With present surgical facilities, death from such an injury should be unusual

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154 MARSHALL, E (1899) An unusual accident (the entire shoulder and arm torn from the body) *N Y med J* **70**, 730

155 POZZAN T (1904) Amputazione interscapolo-toracica per ferita da strappamento dell'arto superiore *Gazz Osp Clin* **25**, 165-68

156 NORTHROP, H L. (1905) Clinical experiences *Hahneman Mon Philad* **40**, 351-58

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[159] RATNAM, C S (1914) Scapulo-thoracic amputation following injury *J Ceylon Br Brit med Ass* **11**, 13-14

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AUTHOR INDEX

SUBJECT INDEX

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